

**SOIL STOCKPILE**  
**STREAMLINED RISK CHARACTERIZATION REPORT**  
**FANSTEEL METALS/FMRI STOCKPILE STRATEGY**  
**MUSKOGEE, MUSKOGEE COUNTY, OKLAHOMA**

## **1 INTRODUCTION**

The purpose of this document is to present the results of a streamlined risk characterization of the soil stockpile area located on the Fansteel Metals/FMRI (Fansteel) site (Site) in Muskogee, Muskogee County, Oklahoma. The risk characterization will also include derivation of potential cleanup levels given various potential applicable or relevant and appropriate requirements (ARARs).

## **2 BACKGROUND**

Fansteel operated a metal processing facility that produced tantalum and columbium metal products from 1957 to 1989. U.S. Environmental Protection Agency (EPA) contractors conducted a Site Inspection (SI) of the Site in October 1981 that included the collection of one soil sample and one sediment sample at outfall and seepage locations from the Site to the Arkansas River. Based on the analytical results, an observed release to surface water was documented [Weston Solutions, Inc. (WESTON), 2019]. In June 2018, the Oklahoma Department of Environmental Quality (ODEQ) performed a Preliminary Reassessment of the Site, the results of which indicated that further sampling at the Site was warranted (same). As part of an Expanded Site Inspection (ESI) conducted at the Site by Superfund Technical Assessment and Response Team (START) in April 2019, one soil sample and one duplicate soil sample were collected from a stockpile of soils located under a tarp and south of the research and development (R&D) building. The stockpile consists of approximately 17,000 cubic yards of soil excavated during the installation of a groundwater inceptor trench in 1999.

Analytical results from the soil stockpile indicated concentrations of the following Hazard Ranking System (HRS) significant contaminants (contaminants considered a hazardous substance with high toxicity/bioaccumulation factor values):

- Semivolatile organic compounds (SVOCs) – acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene,

benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3)pyrene, naphthalene, phenanthrene, pyrene;

- Metals – arsenic, chromium, iron, lead, magnesium, manganese, selenium, silver, zinc, mercury;
- Polychlorinated biphenyls (PCBs) – aroclor 1254; and
- Radionuclides – radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), thorium-230 (Th-230), thorium-232 (Th-232), uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238) above background.

The soil stockpile sample analytical results for SVOCs, metals, and PCBs are provided in Attachment 1. The analytical results for radionuclides are presented in Table 2-1.

**Table 2-1**  
**ESI Soil Stockpile Sample Results – Radionuclides**

Analyte	Soil Stockpile	
	Field Sample	Field Duplicate Sample
	SS-STP-20190408	SS-DUP1-20190408
<b>picoCuries per gram (pCi/g)</b>		
Ra-226	<b>88.1</b>	81.5
Ra-228	<b>18</b>	15.2
Th-228	16.1	<b>18.5</b>
Th-230	63	<b>72</b>
Th-232	15.8	<b>18.6</b>
U-234	42.7	<b>47.3</b>
U-235	2.48	<b>2.69</b>
U-238	44.5	<b>48.7</b>

Weston, 2019

pCi/g -picoCuries

Ra – radium

SS – Soil sample

STP – stockpile

Th – thorium

U – uranium

Bold values are the greater of the normal and duplicate sample results.

U-238 decay chain: U-238, U-234, Th-230, Ra-226

Th-232 decay chain: Th-232, Th-228, Ra-226

U-235 was the only radioisotope analyzed within its decay chain.

In July 2019, EPA National Center for Radiation Field Operations (NCRFO) and EPA Region 6 conducted qualitative gamma survey scans at the Site, including one of the soils stockpiles, using the NCRFO Environmental Radiation Buggy Scanning System. The soils stockpile exhibited significant relative gamma activity, with a maximum measurement of 27 times the background value (National Center for Radiation Field Operations, Office of Radiation and Indoor Air, EPA, 2019). The southern one-third of the stockpile was capped in what appeared to be clean soil that shielded the material beneath to near background values (same).

In their report, the NCRFO noted the gamma scan survey results stated that the raw material (ore) used for tantalum and niobium production contained uranium and thorium as naturally occurring trace constituents. The concentrations of natural uranium and natural thorium were sufficient at Fansteel to cause the ores and slags to be classified as source materials by the Atomic Energy Commission (AEC), which originally issued License No. SMB-911 in 1967 to Fansteel (National Center for Radiation Field Operations, Office of Radiation and Indoor Air, EPA, 2019). The current status of the License can be found at <https://www.nrc.gov/info-finder/decommissioning/complex/fMRI-fansteel-inc.html>.

### **3 STREAMLINED RISK CHARACTERIZATION**

A streamlined risk characterization of the soil stockpile included an analysis of radiological and non-radiological risk.

#### **3.1 RADIOLOGICAL RISK**

The soils stockpile radiological analytical results in Table 2-1 were screened against local background concentrations to determine the contaminants of potential concern (COPCs). No radiological soil background samples were collected at the Fansteel Site during the ESI; however, the sample radiological analytical results were significantly greater than off-site background soil concentrations reported in the Fansteel Decommissioning Plan (Earth Science Consultants, 2003). Off-site soil background concentrations are provided in Table 3-1.

**Table 3-1**  
**Off-site Soil Background Results – Radionuclides**

<b>Analyte</b>	<b>Mean Off-site Soil Background</b>
	<b>picoCuries per gram (pCi/g)</b>
<b>U<sub>total</sub></b>	<b>1.1 +/- 0.6</b>
<b>Th<sub>total</sub></b>	<b>3.3 +/- 0.9</b>
<b>Ra-226</b>	<b>1.0 +/- 0.1</b>
<b>Ra-228</b>	<b>1.2 +/- 0.2</b>

Earth Sciences Consultants, Inc., 2003

Ra – radium

Th - thorium

U – uranium

U<sub>total</sub>: sum of concentrations of U-238, U-235, and U-234

Th<sub>total</sub>: sum of concentrations of Th-234, Th-232, Th-231, Th-230, Th-228, Th-227

Additionally, the soils stockpile exhibited significant relative gamma activity, with a maximum measurement of 27 times background, during a 2019 gamma scan survey by the NCRFO. Therefore, uranium, thorium, and radium were considered COPCs and were carried forward to a streamlined, risk characterization.

Cancer is the major effect of concern from radionuclides. Uranium and thorium occur in three natural decay chains, headed by U-238, U-235, and Th-232, respectively (Attachment 2). Isotopes of radium appear in each of the three decay chains. In nature, the radionuclides in these three chains are approximately in a state of secular equilibrium, in which the activity concentrations of all radionuclides within each series are nearly equal. Additional information on uranium, thorium, and radium at the Fansteel Site can be found in *Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas* (Argonne National Laboratory, 2007).

Using the analytical results in Table 2-1, START calculated the radiological risk of the soils stockpile for an Outdoor Worker with the EPA Preliminary Remediation Goal (PRG) Calculator for Radionuclides (EPA, 2019). START used the greater analytical result between the normal and duplicate samples for each radioisotope to be conservative; results were greater for the duplicate sample for uranium and thorium and greater for the normal sample for radium. It should be noted that based on the single normal and duplicate sample results of the soils stockpile, the Th-232 decay chain appears to be essentially in equilibrium, whereas the U-238 decay chain shows the

Ra-226 concentration approximately 22% greater than the Th-230 concentration and approximately 84% greater than the U-238 and U-234 concentrations. Therefore, the concentration for Th-232 was used for the entire decay chain. Within the U-238 decay chain, secular equilibrium was assumed for “sub-” decay chains U-238 through protactinium-234 (Pa-234) and Ra-226 through polonium-210 (Po-210). The entire U-235 decay chain was assumed to be in secular equilibrium, given that a result is provided solely for U-235. (Although the U-235 decay chain may likely exhibit a similar disequilibrium ratio as the U-238 decay chain (Ra-226 concentration 84% greater than U-238 concentration) between Ra-223 and U-235, the risk of the U-235 decay chain in equilibrium contributes only 0.6% of the total risk. Noting that radiological risk is linear, doubling the risk of the U-235 decay chain [100% disequilibrium] would result in the risk of the U-235 decay chain contributing only 0.8% of the total risk and is deemed inconsequential, given the level of effort required to apply unequal concentrations.)

Three exposure pathways are included in the Outdoor Worker land-use template in the Preliminary Remediation Goal (PRG) Calculator: (1) incidental ingestion of soil; (2) inhalation of soil particulates; and (3) external exposure to gamma radiation in soil. PRG default values, which represent reasonable maximum exposure to broad-based populations, and are typically 90 to 95 percentile values and well above the mean, were used for all parameter values except for the area of contamination. A contaminated area of 2,000 square meters ( $m^2$ ) was used; the approximate, conservative size of the soils stockpile using the scale on the ESI Sample Location Map (WESTON, 2019). Although the southern one-third of the stockpile was capped in what appeared to be clean soil that shielded the material beneath to near background values, which would result in a more realistic contaminated area of approximately 1,333  $m^2$ , the nearest value in the PRG Calculator parameter menu above 1,333 was 2,000  $m^2$ . The input values are provided in Attachment 3.

The risk of the soils stockpile for an Outdoor Worker calculated to

$$4.33 \times 10^{-3},$$

an order of magnitude greater than the largest value of the range within which EPA manages excess lifetime carcinogenic morbidity risk,  $10^{-4}$  to  $10^{-6}$ . The U-238, U-235, and Th-232 decay-chain

radioisotopes are contaminants of concern (COCs). The PRG Calculator risk output is provided in Attachment 3.

### **3.1.1 Principal Threat Waste**

The *EPA A Guidance on Principal Threat and Low Level Threat Waste* recommends treatment of principal threat waste when practicable (EPA, 1991). The guidance aligns with, and supports, the National Contingency Plan (NCP), promulgated on 8 March 1990 that states that EPA expects to use treatment to address the principal threats posed by a site, wherever practicable (40 Code of Federal Regulations [CFR] Section 300.430(a)(1)(iii)). No “threshold level” of toxicity/risk has been established to equate to “principal threat”; however, where toxicity and mobility of source material combine to pose a potential risk of  $10^{-3}$  or greater, generally, treatment alternatives should be evaluated (same). Based on a risk of  $4.33 \times 10^{-3}$ , the soils stockpile meets the *general* definition of a principal threat waste.

### **3.1.2 ARARs and TBCs**

All remedial actions at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites must be protective of human health and the environment and must comply with ARARs unless a waiver is justified. Cleanup levels for response actions under CERCLA are developed based on site-specific risk assessments, ARARs, and/or to-be-considered (TBC) material. The determination of whether a requirement is applicable, or relevant and appropriate, must be made on a site-specific basis (40 CFR Part 300.400(g)).

#### **3.1.2.1 *EPA Regulations***

EPA regulations that apply to soil concentrations of radioactive elements are promulgated in 40 CFR 192, entitled, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings." In 1983, EPA promulgated in 40 CRF 192, Subpart B *Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites*. These standards were developed pursuant to Section 275 of the Atomic Energy Act (AEA) of 1954, as amended by Section 206 of the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, and were developed specifically for the cleanup of uranium mill tailings at 24 named sites designated under Section 102(a)(1) of Uranium Mill Tailings Radiation Control Act (UMTRCA) (Title 1 sites). The list of 24 Title 1 sites is a closed set chosen in 1979, to which

additional sites cannot be added. 40 CFR 192.12(a) specifies that the concentration of Ra-226 in land averaged over an area of 100 m<sup>2</sup> shall not exceed background by more than:

1. Five picoCuries per gram (pCi/g) averaged over the first 15 centimeters (cm) of soil below the surface; and
2. Fifteen pCi/g averaged over 15 cm-thick layers of soil more than 15 cm below the surface.

40 CFR 192.12(b) further stipulates that *in any occupied or habitable building*:

1. The objective of any remedial action, within reasonable means, should be to achieve an annual average (or equivalent) radon product concentration (including background) not to exceed 0.02 working level (“WL”), and that in any case 0.03 WL should not be exceeded; and
2. Gamma radiation levels should not exceed 20 microRoentgens per hour ( $\mu\text{R}/\text{hr}$ ) above background.

Note that the concentration criterion for subsurface soils, 15 pCi/g, is not a health-based standard, but was developed for use in limited circumstances as a tool for locating and remediating discrete deposits of high, subsurface radioactivity (greater than 30 pCi/g; typically 300 to 1,000 pCi/g) in subsurface locations at mills. The 15 pCi/g subsurface standard is expected to achieve, in fact, an actual subsurface cleanup level of 5 pCi/g (EPA, 1998).

The 5 pCi/g and 15 pCi/g standards were initially developed for the single radionuclide Ra-226; however, in Subpart E of 40 CFR 192, *Standards for Management of Thorium Byproduct Pursuant to Section 84 of the AEA of 1954, as Amended*, EPA determined that the standards were suitable for remediation of Ra-228, a radioisotope in the Th-232 decay chain, at Title II sites. Uranium-ore-processing sites addressed by Title II of UMTRCA were active when the act was passed in 1978.

The standards contained within Subparts B and E of 40 CFR 192 **are potentially applicable requirements for UMTRCA Title I and Title II sites only**, respectively (EPA, 1998). Waste rock or ore stock piles at abandoned or active metal processing facilities such as Fansteel are not subject to these regulations, since these materials have not been milled or processed specifically for uranium. That is, Fansteel is neither an UMTRCA Title I nor Title II site.

However, if the contaminants at a site are the same (i.e. Ra-226, Ra-228, and/or thorium) and the distribution of contamination (little subsurface contamination between 5 pCi/g and 30 pCi/g; i.e.,

most subsurface contamination is greater than 30 pCi/g) is similar to that of Title I and Title II sites, the UMTRCA soil cleanup standards **may be *relevant and appropriate* requirements for CERCLA sites** (EPA, 1998). Because the risk from uranium and thorium byproducts is additive (i.e., both carcinogenic risk), these standards should apply to the combined level of contamination of Ra-226 and Ra-228. Note that to achieve a permanent cleanup objective of 5 pCi/g for Ra-226 and Ra-228, there needs to be assurance that the preceding radionuclides in the decay chains will not be left behind at levels that will permit the combined radium activity to build up to levels greater than 5 pCi/g after the completion of the response action. At a minimum, this means that Th-230 and Th-232 should be cleaned up to the same combined 5 pCi/g as their radium daughters.

For cover-material performance on inactive uranium and thorium mill sites, 40 CFR 192.32(a)(4) establishes the standard for radon-222 (Rn-222) flux at 20 picoCuries/square meter-second (pCi/m<sup>2</sup>-s). Additionally, implemented control measures must remain effective for up to 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years [40 CFR 192.32(b)(1)(i)]. Although *not applicable* requirements, these cover-material performance standards **are potentially *relevant and appropriate* requirements** for CERCLA sites and thus the Fansteel Site.

Finally, CERCLA Removal Process defined in 40 CFR 300.415 establishes methods and criteria for determining the extent of response when there is a release into the environment of a hazardous substance or any pollutant that may represent an imminent and substantial danger to public health or welfare. The goal of the investigation and remedy selection process under CERCLA is to select remedies that are protective of both human health and the environment, that maintain protection over time, and that minimize untreated waste. The investigation and evaluation of remedies is described in 40 CFR 300.430 – Remedial Investigation/Feasibility Study (RI/FS) and Selection of Remedy. Under CERCLA, remediation goals, which establish acceptable contaminant exposure levels that will be protective both of the environment and of human health under consideration of all potential exposure pathways, are developed by considering ARARs, if available, as well as factors including: For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10<sup>-4</sup> and 10<sup>-6</sup>. Risk-based soil action levels can be developed thusly via EPA’s online PRG Calculator for radionuclides. The CERCLA RI/FS process does not specifically apply to sites that

are not listed on the National Priorities List and thus **may not be an applicable requirement** for the Fansteel Site. However, the CERCLA RI/FS process **is a potentially relevant and appropriate requirement.**

### **3.1.2.2 NRC Regulations**

National Response Center (NRC) regulations that relate specifically to protection of the general public from radiation are promulgated in 10 CFR 20: “Standards for protection against radiation,” 10 CFR 40: “Domestic licensing of source material,” and 10 CFR 61: “Licensing requirements for land disposal of radioactive waste.” In 1985, the NRC promulgated standards under 10 CFR 40 (NRC’s UMTRCA Rule) to address uranium mill tailings. The radium soil standards were intended as conforming standards to EPA’s UMTRCA soil standards under 40 CFR 192 for Ra-226 and Ra-228, as detailed in Section 3.1.2.1.

The Fansteel Site is currently implementing a decommissioning plan pursuant to 10 CFR 20, Part E (20.1403) (<https://www.nrc.gov/info-finder/decommissioning/complex/fMRI-fansteel-inc.html>). These regulations state, in part, the following:

1. The licensee has made provisions for legally enforceable institutional controls that provide reasonable assurance that the Total Effective Dose Equivalent (TEDE) from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 millirem per year (mrem/yr).
2. Residual radioactivity at the site has been reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable and would not exceed either:
  - a. 100 mrem/yr; or
  - b. 500 mrem/yr, provided that the licensee demonstrates that further reductions in residual radioactivity necessary to achieve 100 mrem/yr are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm.

The regulations in 10 CFR 20 **are potential applicable requirements.** Note that the Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-20, *Radiation Risk Assessment at CERCLA Sites: Q&A*, provides the Superfund guidance on what is considered a protective dose-based ARAR as 12 millirems per year (mrem/yr) above background, which achieves a  $3 \times 10^{-4}$  cancer morbidity risk (EPA, 2014). Under this guidance, a protective dose would need to equal

12 mrem/yr or less; if not, 12 mrem/yr would ‘override’ the NRC protective dose of 25 mrem/yr (or 100/500 mrem/yr) as the CERCLA site cleanup level. This CERCLA risk assessment guidance **is a potential TBC**.

In 1999, the NRC amended its UMTRCA Rule by adding Criterion 6(6) to Appendix A *Radiological Criteria for License Termination of Uranium Recovery Facilities*. The amendment uses the existing soil radium standard (5 pCi/g surface; 15 pCi/g subsurface) to derive a dose criterion (benchmark approach) for cleanup of byproduct material, including radium, in soil and surface activity on structures. In areas where there is more than one residual radionuclide (i.e. radium, thorium, uranium), the benchmark dose applies to the sum of all radionuclide concentrations in that area. The benchmark approach requires licensees subject to the rule to calculate the potential peak dose to an individual at the site within 1,000 years from exposure to the residual levels allowed under the UMTRCA soil standard, excluding radon (radon is a radioisotope in the U-238, U-235, and Th-232 decay chains). Licensees are then to remediate the site such that all residual radionuclide concentrations remaining post-remediation on the site do not result in a dose greater than the calculated potential peak benchmark dose. Criterion 6(6) addresses the lack of remediation standards for radionuclides other than radium in soil at uranium recovery facilities, including radioisotopes above (e.g., Th-232, Th-230) and below (e.g., Pb-210 in U-238 decay chain) radium in the U-238 and Th-232 decay chains.

The radium benchmark dose standards contained within Criterion 6(6) **are potential applicable requirements** only for UMTRCA Title II sites. Again, Title II of UMTRCA addresses uranium-ore-processing sites that were active when the act was passed in 1978. Waste rock or ore stock piles at abandoned or active metal processing facilities such as Fansteel are not subject to these regulations, since these materials have not been milled specifically for uranium. As stated previously, Fansteel is not a Title II site.

However, if the majority of radiological risk posed by contaminants in the soil at a site are the same (i.e., radium, thorium, uranium) as those existing at UMTRCA Title II sites, the Criterion 6(6) radium benchmark dose limit **is a potentially relevant and appropriate requirement** for those contaminants at a CERCLA site (EPA, 2000a). Note that assumptions used in rulemaking documents during the development of Criterion 6(6) and/or found in accompanying NRC guidance

documents, such as NRC's dose assessment methodology or its land-use assumption that the uranium recovery sites would be released for unrestricted use, would generally **not be considered relevant and appropriate** requirements under CERCLA (same). Benchmark Dose assessments *should* use, however, reasonable maximum exposure parameter values, i.e.; typically 90 to 95 percentile values and well above the mean, that are consistent with the reasonably anticipated future land use of the site (same). The radium benchmark dose from soil at CERCLA sites should be met for the sum of doses for both soil and structures (same).

Note that when developing a radium benchmark dose per Criterion 6(6) as a relevant and appropriate requirement for both surface and subsurface soils, a concentration value for radium of 5 pCi/g should be used, as opposed to using 15 pCi/g for subsurface soils. The reasons are stated in Section 3.1.2.1.

Note further that OSWER Directive 9285.6-20, *Radiation Risk Assessment at CERCLA Sites: Q&A*, referenced previously, provides the Superfund guidance on what is considered a protective dose-based ARAR as 12 mrem/yr, which achieves a  $3 \times 10^{-4}$  cancer morbidity risk (EPA, 2014). Under this guidance, a radium benchmark dose would need to equal 12 mrem/yr or less; if not, 12 mrem/yr would ‘override’ the radium benchmark dose as the CERCLA site cleanup level. This fact is noted in OSWER Directive 9200.4-35P (EPA, 2000a); however, it considers 15 mrem/yr as presumptively protective of human health, which has been superseded by 12 mrem/yr per OSWER 9285.6-20. As stated previously, this CERCLA risk assessment guidance is a potential TBC.

### 3.1.2.3 MARSSIM

The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) provides a multi-agency (EPA, NRC, Department of Energy [DOE]) approach to conducting radiation surveys and investigations at potentially contaminated sites, with a focus on contaminated surface soil and building surfaces. The purpose of MARSSIM is to provide a standardized approach to demonstrating compliance with a dose- or risk-based regulation. MARSSIM does not establish cleanup criteria for reclamation of radioactively contaminated sites, but states that the affiliated agencies' regulations and policies support 15 mrem/yr and/or 25 mrem/yr dose-based health-protective standards (EPA, 2000b). EPA's dose-based health protective standard was revised from 15 mrem/yr to 12 mrem/yr in 2014 after the publication of MARSSIM; 12 mrem/yr is equivalent

to a carcinogenic morbidity risk of  $3 \times 10^{-4}$  (EPA, 2014). MARSSIM is guidance, not a promulgated standard, and thus is not an ARAR, though **it may be applied as a TBC**.

### **3.1.2.4 OSHA**

The Occupational Safety and Health Administration (OSHA) has promulgated standards for the protection of workers who may be exposed to hazardous substances at Resource Conservation and Recovery Act (RCRA) or CERCLA sites (29 CFR Parts 1910.1096, 1910.120, and 1926.65). EPA requires compliance with OSHA standards in the NCP (40 CFR 300.150), but not through the ARAR process. Therefore, **OSHA standards are not considered ARARs**. Since the requirements, standards, and regulations of OSHA are not ARARs and cannot be waived, they would be complied with during the removal action.

### **3.1.2.5 State Regulations**

Oklahoma has not promulgated standards or established guidelines for the protection from radiation in soils. Two states, Texas and New Mexico, have such standards and guidelines that may be instructive as TBCs for the Fansteel Site. Texas has promulgated standards for the protection from radiation in soils, while New Mexico has established guidelines for the cleanup and reclamation of existing uranium mining operations. Title 30 of the Texas Administrative Code (TAC), Section 336.1115(e), establishes soil cleanup standards for Ra-226 and Ra-228 at source-material recovery facilities. Under Section 336.1115(e), outdoor areas are considered suitable for release for unrestricted use if the concentration of Ra-226 or Ra-228 in soil, averaged over any 100 m<sup>2</sup>, does not exceed the background level by more than 5 pCi/g averaged over the first 15 cm of soil below the surface, and may not exceed the background level by more than 15 pCi/g, averaged over 15 cm-thick layers of soil more than 15 cm below the surface.

Additionally, Section 336.1115(e) states that byproduct material containing concentrations of radionuclides other than radium in soil (e.g., natural uranium, natural thorium, lead-210) must not result in a total dose exceeding the dose from cleanup of radium-contaminated soil to the standard listed in the preceding paragraph and must be at levels that are as low as reasonably achievable (ALARA). This dose is referred to as the radium benchmark dose. Section 336.1115(e) is compatible with the NRC's standards under 10 CFR Part 40 (NRC's UMTRCA Rule) to address

uranium mill tailings and the NRC's 1999 UMTRCA Rule Amendment Criterion 6(6) to Appendix A.

New Mexico established guidance in 2016 to assist mine site responsible parties in addressing soil radiation at existing uranium mines as part of reclamation activities (New Mexico Energy, Minerals and Natural Resources Department [NMEMNRD] and New Mexico Environment Department [NMED], 2016). Surface reclamation of mine sites falls under the jurisdiction of the New Mexico Mining Act (NMMA). The NMMA is administered under the New Mexico Mining Commission (NMMC) regulations (19.10 New Mexico Administrative Code [NMAC]). The NMMC regulations apply to all currently-operating mines as well as to mines that operated for a minimum of 2 years between 1 January 1970 and 18 June 1993, which is the effective date of the NMMA.

The guidance states that the goal of mitigating mine site radiation levels is to be compliant with 40 CFR 192.12, 40 CFR 192.32, and 10 CFR 40, such that remedial actions shall provide reasonable assurance that:

1. The concentration of Ra-226 in land averaged over any area of 100 m<sup>2</sup> shall not exceed the background level by more than:
  - a) 5 pCi/g, averaged over the first 15 cm of soil below the surface and
  - b) 15 pCi/g, averaged over 15 cm-thick layers of soil more than 15 cm below the surface.
2. Site post-reclamation radiation level (PRRL) for gamma radiation should not exceed the site-specific value of gamma radiation that correlates to 5 pCi/g Ra-226 above background at the 95th percentile value. For example, at an existing mine site, the value of gamma radiation that correlates to a maximum Ra-226 activity of 5 pCi/g above background in soil may be determined to be 20 µR/hr above background, which would then be designated as the site-specific PRRL.
3. For sites at which contaminated material exceeding the target radium activity level discussed above is emplaced in an on-site repository, cover material for the repository must achieve radon flux equal or less than 20 pCi/m<sup>2</sup>-s.

The New Mexico guidelines do not include the radium benchmark approach under the NRC's UMTRCA Rule amendment Criterion 6(6) to Appendix A. The Texas regulations and New Mexico guidelines are state-specific and **cannot be ARARs** for the Fansteel Site. However, **both are potential TBCs**.

### 3.1.2.6 Summary of ARARs and TBCs

A summary of potential ARARs and TBCs described in Sections 3.1.2.1 through 3.1.2.5 is provided in Table 3-1.

**Table 3-1**  
**Potential ARARs and TBCs**

Agency	Description and Reference	Standard	Potential ARAR or TBC?
EPA	40 CFR 192 UMTRCA Rule	Per 100 m <sup>2</sup> , 5 pCi/g Ra-226 for surface/ subsurface or 15 pCi/g below 15 cm for discrete, high-activity pockets. Rn-222 flux of 20 pCi/m <sup>2</sup> -s for cover material.	Yes, ARAR
EPA	40 CFR 300.430 CERCLA RI/FS Process and Guidance	None; Soil action levels can be developed via PRG Calculator to achieve cancer risk between 10-4 and 10-6. Guidance proposes max 12 mrem/yr target dose for dose-based ARARs as protective, equal to risk of 3x10-4	Yes, ARAR (RI/FS Process); TBC (Guidance)
NRC	10 CFR 20, Part E (20.1403)	With institutional controls, TEDE above background of 25 mrem/yr; 100 mrem/yr if controls removed or 500 mrem/yr if conditions met.	Yes, ARAR (EPA CERCLA Guidance of 12 mrem/yr may 'override' as TBC)
NRC	10 CFR 40 UMTRCA Rule plus Criterion 6(6) to Appendix A	Same as EPA UMTICA Rule, plus Radium Benchmark Dose (Target dose from all residual radioisotopes, excluding radon, = dose from 5 pCi/g Ra-226)	Yes, ARAR
EPA, NRC, DOE	MARSSIM; joint guidance to meet Agencies' radiation regulations for soil and structures	None; supports EPA (12 mrem/yr) and DOE/NRC (25 mem/yr) protective dose targets	Yes, TBC
OSHA	29 CFR Part 1910.1096	None; Rad Worker exposure standard of 5,000 mrem/yr	No
Texas	TAC Section 336.1115(e)	Similar to NRC UMTICA standard	Yes, TBC

<b>Agency</b>	<b>Description and Reference</b>	<b>Standard</b>	<b>Potential ARAR or TBC?</b>
New Mexico	19.10 NMAC	Similar to EPA UMTRCA standard	Yes, TBC
Oklahoma	-	No soils standard or guidance	-

### **3.2 NON-RADIOLOGICAL RISK**

Given time and budget constraints for this streamlined risk characterization, the non-radioactive risk (metals, PCBs, SVOCs) posed by the soils stockpile was not evaluated. Given the nature of the stockpile as having a reasonably known extent of contamination, both horizontally and vertically, any removal action contemplated to address the radioactive risk of the stockpile will also address the non-radioactive risk.

## **4 CLEANUP LEVEL**

Three potential radioactive risk-associated ARARs described in Sections 3.1.2.1 and 3.1.2.2 require additional calculations to show compliance with their requirements. The potential ARARs are the 40 CFR 192.32(a)(4) standard, which requires calculation of a cover-thickness that would achieve Rn-222 flux of 20 pCi/m<sup>2</sup>-s; 10 CFR 40 Criterion 6(6) to Appendix A, which requires calculation of a Radium Benchmark Dose and then Single Radionuclide Guideline Level concentrations for all present residual radionuclides that would, combined, achieve the Radium Benchmark Dose; and 40 CFR 300.430, which requires, if the soil stockpile were left in place, calculation of a cover-thickness that would achieve a cancer morbidity risk of 10<sup>-4</sup> to 10<sup>-6</sup>.

### **4.1 REPOSITORY COVER THICKNESS FOR RN-222 FLUX**

Pursuant to 40 CFR 192.32(a)(4) as a potential relevant and appropriate requirement at the Site, a repository cover thickness that would achieve Rn-222 flux of 20 pCi/m<sup>2</sup>-s, given the soils stockpile maximum sample radium result of 88.1 pCi/g, was calculated using formulas from NRC Regulatory Guide 3.64 (NRC, 1989). A sufficient cover thickness was calculated to be:

**60 cm (approximately 2 feet).**

However, since it is unknown how representative the single grab soil sample is of the stockpile, cover thicknesses were calculated to achieve Rn-222 flux of 20 pCi/m<sup>2</sup>/s for radium concentrations that range from less than to greater than 88.1 pCi/g.

**23 cm (approximately 0.75 feet), assuming 44 pCi/g Ra-226**  
**40 cm (approximately 1.31 feet), assuming 60 pCi/g Ra-226**  
**67 cm (approximately 2.20 feet), assuming 100 pCi/g Ra-226**  
**78 cm (approximately 2.56 feet), assuming 125 pCi/g Ra-226**

The repository cover-thickness calculation results are provided as Attachment 4.

## **4.2 RADIUM BENCHMARK DOSE**

Pursuant to 10 CFR 40, Criterion 6(6) to Appendix A as a potential relevant and appropriate requirement at the Site, a Radium Benchmark Dose was calculated using DOE's Residential Radioactive (RESRAD) On-Site Code (Argonne National Laboratory, 2016). The same Outdoor Worker scenario was established in RESRAD as the one used for the risk calculation in the PRG Calculator in Section 4.1, with three pathways of exposure: (1) incidental ingestion of soil; (2) inhalation of soil particulates; and (3) external exposure to gamma radiation in soil. To the maximum extent possible, the default parameter values in the PRG Calculator Outdoor Worker scenario were used; otherwise, RESRAD default values were used, which also represent reasonable maximum exposure values. PRG Calculator default values for inhalation rate, exposure duration, outdoor and indoor time fractions, and soil ingestion rate were able to be used as RESRAD input parameters. A site-specific, contaminated area of 2,000 m<sup>2</sup> was used, the approximate size of the soils stockpile (the area of the soils stockpile is approximately 2,800 m<sup>2</sup> [conversation with Site personnel]; however, the PRG Calculator requires selection of 'contaminated area' from a pre-set menu that includes the closest available values of 2,000 m<sup>2</sup> and 5,000 m<sup>2</sup>). The input values are provided in Attachment 5.

The Radium Benchmark Dose for an Outdoor Worker exposed to 5 pCi/g of Ra-226 calculated to:

**8.41 mrem/yr at t=0.0 years.**

Note that this value is below the recommended maximum protective dose per CERCLA guidance (EPA, 2014) of 12 mrem/yr. The RESRAD Radium Benchmark Dose output is provided in Attachment 5.

Using the Radium Benchmark Dose of 8.41 mrem/yr, Single Radionuclide Guideline Level (SRGL) concentrations were then calculated with the RESRAD On-Site Code for radionuclides in the U-238, Th-232, and U-235 decay chains. The same input parameter values as described for calculation of the Radium Benchmark Dose for an Outdoor Worker were used in the calculations. The SRGL concentrations at the time of maximum dose ( $t=0.0$  years) can be found in the RESRAD output provided in Attachment 6 (page 24) and in Table 4-1.

The SRGLs are the concentrations at which each subject radionuclide would alone produce a dose equivalent to the radium benchmark dose of 8.41 mrem/yr. The SRGL concentrations should be used with the Unity Rule to ensure that the sum of the ratios of each radioisotope to its SRGL equals less than Unity, i.e., '1'.

**Table 4-1**  
**Single Radionuclide Guideline Levels**  
**Target Maximum Acceptable Dose = Radium Benchmark Dose = 8.41 mrem/yr**

<b>Uranium-238 Decay Chain</b>	
	<b>picocuries per gram (pCi/g)</b>
U-238	281
U-234	3,382
Th-230	418
<b>Ra-226</b>	<b>5.00</b>
Pb-210	243
Po-210	647
<b>Uranium-235 Decay Chain</b>	
U-235	61.0
<b>Thorium-232 Decay Chain</b>	
Th-232	104
Ra-228	8.19
Th-228	7.03

As an alternative to the SRGLs, a ‘cumulative’ action level for Ra-226 can be calculated that accounts for all risk from the U-238, U-235, and Th-232 decay chains, under the assumption that the ratios of the concentrations of other radioisotopes in each of these decay chains to the Ra-226 concentration in the ESI soil stockpile sample are characteristic of the entire soil stockpile. To this end, a concentration of 1 pCi/g for Ra-226 and the ratio of the concentration of each radioisotope in Table 2-1 to the Ra-226 concentration were used as input concentration values in RESRAD. The total annual dose for these concentrations for an Outdoor Worker calculated to 2.26 mrem/yr at t = 0.0 years (see page 13 of Attachment 6). Dividing 2.26 mrem/yr per 1 pCi/g of Ra-226 into the Radium Benchmark Dose value of 8.41 mrem/yr yields a ‘cumulative’ action level of:

**3.72 pCi/g of Ra-226.**

In this manner, the ‘cumulative’ action level for Ra-226 can be used without employing the Unity Rule. The ‘cumulative’ action level would provide a savings to post-removal, confirmation sample analytical costs by requiring analysis solely for Ra-226.

#### **4.3 CANCER MORBIDITY RISK RANGE OF 10<sup>-4</sup> TO 10<sup>-6</sup>**

Pursuant to 40 CFR 300.430 as a potential relevant and appropriate requirement at the Site, a cover thickness that would achieve a cancer morbidity risk of 10<sup>-4</sup> to 10<sup>-6</sup>, if the soils stockpile were left in place, was calculated with the maximum stockpile sample radium result of 88.1 pCi/g for an Outdoor Worker with the EPA PRG Calculator for Radionuclides (EPA, 2019). A target maximum risk level of 3x10<sup>-4</sup> was used based on OSWER Directive 92856.6-20 (EPA, 2014). To save time and effort, the calculation was performed using just Ra-226 and progeny, since it is, to a significant degree, the largest contributor of risk for an Outdoor Worker. A sufficient cover-thickness was calculated to be:

**30 cm (approximately 1 foot) (2.7x10<sup>-4</sup> risk).**

However, since it is unknown how representative the single, grab, soil sample is of the stockpile, cover-thicknesses were calculated to achieve 3x10<sup>-4</sup> risk for radium concentrations that range from less than to greater than 88.1 pCi/g.

**18 cm (approximately 0.59 feet), assuming 44 pCi/g Ra-226**

**26 cm (approximately 0.85 feet), assuming 60 pCi/g Ra-226**

**30 cm (approximately 0.98 feet), assuming 100 pCi/g Ra-226**

**40 cm (approximately 1.31 feet), assuming 125 pCi/g Ra-226**

The stockpile cover-thickness calculation results are provided as Attachment 7.

## **5 CONCLUSION**

Based on the analytical results of one soil sample collected at the soils stockpile on the Site during the April 2019 ESI, the radiological risk of the soils stockpile to an Outdoor Worker, using the Outdoor Worker template in EPA's PRG Calculator for Radionuclides, equals **4.33x10<sup>-3</sup>**, an order of magnitude greater than the largest value of the range within which EPA manages excess lifetime carcinogenic morbidity risk, 10<sup>-4</sup> to 10<sup>-6</sup>. Based on this risk, the radioisotopes of the U-238, U-235, and Th-232 decay chains are COCs. Further, based on this risk, the soils stockpile meets the *general* definition of a principal threat waste.

Pursuant to EPA's UMTRCA Rule as a potential ARAR for an emergency removal at the Site, a cover-thickness for a remedy that would include capping the soils stockpile in place was calculated using radon flux formulas in NRC Regulatory Guide 3.6.4 to equal **60 cm (approximately 2 feet)**. Additional cover-thicknesses were calculated assuming varying representative Ra-226 concentrations of the soils stockpile other than a single, grab sample result; using Ra-226 concentrations of 44, 60, 100, and 125 pCi/g, cover-thicknesses ranged from **23 cm (0.75 feet) to 78 cm (2.56 feet)**.

Pursuant to 40 CFR 300.430 as a potential ARAR for an emergency removal at the Site, a cover-thickness for a remedy that would include capping the soils stockpile in place was calculated with the EPA PRG Calculator for Radionuclides to equal **30 cm (approximately 1 foot)**. Additional cover-thicknesses were calculated assuming varying representative Ra-226 concentrations of the soils stockpile other than a single grab sample result; using Ra-226 concentrations of 44, 60, 100, and 125 pCi/g, cover-thicknesses ranged from **18 cm (0.59 feet) to 40 cm (1.31 feet)**.

Thus, for a potential remedy of capping the soils stockpile in place, assuming a possible range of Ra-226 concentrations from 44 pCi/g to 125 pCi/g represent the stockpile accurately, soil cover-thicknesses ranging from **18 cm (approximately 0.6 feet) to 78 cm (approximately 2.6 feet)** would provide protection required if EPA's UMTRCA Rule and 40 CFR 300.430 were considered ARARs and/or TBCs.

Finally, pursuant to NRC's UMTRCA Rule Criterion 6(6) to Appendix A as a potential ARAR for a remedy that would include removal of the soils stockpile (e.g., for off-site disposal), a radium benchmark dose was calculated with DOE's RESRAD On-Site 7.2 Code to equal **8.41 mrem/yr**; associated SRGLs were also calculated with RESRAD and are provided in Table 4-1. Finally, as an alternative to the SRGLs, and as a potential analytical cost-saving measure, a 'cumulative' action level for Ra-226 that accounts for all residual radionuclide risk at the Site was calculated with RESRAD to equal **3.72 pCi/g of Ra-226**.

Given time and budget constraints for this streamlined risk characterization, the non-radiological risk posed by the soils stockpile was not evaluated. Given the nature of the stockpile as having a reasonable known extent of contamination both horizontally and vertically, however, any removal action contemplated to address the radiological risk of the stockpile will also address the non-radiological risk.

## 6 REFERENCES

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## 7 ATTACHMENTS

- |              |   |
|--------------|---|
| Attachment 1 | ESI Soils Stockpile Sample Results – SVOCs, Metals, and PCBs                      |
| Attachment 2 | Uranium and Thorium Decay Chains  |
| Attachment 3 | PRG Calculator Risk Calculation Results   |
| Attachment 4 | Cover Thickness Calculation Results for Radon Flux                                |
| Attachment 5 | RESRAD Radium Benchmark Dose Calculation Results                                  |
| Attachment 6 | RESRAD Single Radionuclide Guideline Level Calculation Results                    |
| Attachment 7 | Cover Thickness Calculation Results for Target Maximum Risk of $3 \times 10^{-4}$ |

**ATTACHMENT 1**  
**ESI SOILS STOCKPILE SAMPLE RESULTS – SVOCs,  
METALS, AND PCBs**

**Table 4-2**  
**Summary of ESI Source Sediment and Soil Analytical Data**

Fansteel Metals/FMRI

EPA Region 6

Analyte	SCDM Benchmark (lowest value)	Background (SED-BKG) or RL	CAS.NO	Units	Station Sample ID Date Type	P8 SED-P8-20190408 4/8/2019 Field Sample	P8 SED-DUP1-20190408 4/8/2019 Field Duplicate	P9 SED-P9-20190408 4/8/2019 Field Sample	SS SS-STP-20190408 4/8/2019 Field Sample	SS SS-DUP1-20190408 4/8/2019 Field Duplicate	
<b>SVOC</b>											
1,1,Â'-Biphenyl	-	8.1	92-52-4	ug/kg	--	9.5	U	9.8	U	9.2	U
2,3,4,6-Tetrachlorophenol	-	8.1	58-90-2	ug/kg	--	16	U	17	U	16	U
2,4,6-Trichlorophenol		8.1	88-06-2	ug/kg	--	9.5	U	9.8	U	9.2	U
2,4-Dichlorophenol	4000	8.1	120-83-2	ug/kg	--	7.3	U	7.5	U	7	U
2-Methylnaphthalene	6000	8.1	91-57-6	ug/kg	--	2.8	U	2.9	U	19	
3&4-Methylphenol	100000	8.1	3/4-CRESOL	ug/kg	--	5.6	U	5.8	U	5.4	U
Acenaphthene	90000	4.1	83-32-9	ug/kg	--	2.8	U	2.9	U	2.7	U
Anthracene	400000	4.1	120-12-7	ug/kg	--	3	JQ	7.2	JQ	2.7	U
Benz(a)anthracene	40	4.1	56-55-3	ug/kg	--	13	JQ	9.3	U	8.7	U
Benzaldehyde	-	8.1	100-52-7	ug/kg	--	38	n	6.9	U	6.5	U
Benzo(a)pyrene	4	4.1	50-32-8	ug/kg	--	13	JQ	8.2	JQ	14	JQ
Benzo(b)fluoranthene	-	4.1	205-99-2	ug/kg	--	18	JQ	18	JQ	6.5	U
Benzo(g,h,i)perylene	-	4.1	191-24-2	ug/kg	--	3.9	U	4.1	U	3.8	U
Benzo(k)fluoranthene	400	4.1	207-08-9	ug/kg	--	14	JQ	6.4	JQ	12	JQ
Bis(2-ethylhexyl)phthalate	290	8.1	117-81-7	ug/kg	--	19	JQ	12	JQ	39	
Butyl benzyl phthalate	2100	8.1	85-68-7	ug/kg	--	7.3	U	7.5	U	7	U
Carbazole	-	8.1	86-74-8	ug/kg	--	6.7	U	6.9	U	6.5	U
Chrysene	4000	4.1	218-01-9	ug/kg	--	19		12	JQ	4.3	U
Dibenz(a,h)anthracene	4	4.1	53-70-3	ug/kg	--	9	U	9.3	U	8.7	U
Dibenzofuran	1000	4.1	132-64-9	ug/kg	--	3.9	U	6.9	JQ	3.8	U
Di-n-butyl phthalate	100000	8.1	84-74-2	ug/kg	--	6.7	U	6.9	U	6.5	U
Fluoranthene	60000	4.1	206-44-0	ug/kg	--	35		21		16	JQ
Fluorene	60000	4.1	86-73-7	ug/kg	--	6.2	U	10	JQ	6	U
Indeno(1,2,3-cd)pyrene	400	4.1	193-39-5	ug/kg	--	8.5	JQ	4.6	U	4.3	U
Naphthalene	30000	4.1	91-20-3	ug/kg	--	3.4	U	3.5	U	3.2	U
Pentachlorophenol	10	8.1	87-86-5	ug/kg	--	19	U	19	U	18	U
Phenanthrene	-	4.1	85-01-8	ug/kg	--	23		49		18	JQ
Pyrene	40000	4.1	129-00-0	ug/kg	--	28		16	JQ	25	
<b>PCBs</b>											
Aroclor-1254	2	21	11097-69-1	ug/Kg-dry	--	19	U	20	U	19	U
<b>VOC</b>											
Toluene	100,000	5	108-88-3	ug/Kg-dry	--	6	JQ	2.4	U	1.8	U
										1.7	JQ
										1.5	JQ



**Table 4-2**  
**Summary of ESI Source Sediment and Soil Analytical Data**  
**Fansteel Metals/FMRI**  
**EPA Region 6**

Analyte	SCDM Benchmark (lowest value)	Background (SED-BKG) or RL	CAS.NO	Units	Station Sample ID Date Type	P8 SED-P8-20190408 4/8/2019 Field Sample	P8 SED-DUP1-20190408 4/8/2019 Field Duplicate	P9 SED-P9-20190408 4/8/2019 Field Sample	SS SS-STP-20190408 4/8/2019 Field Sample	SS SS-DUP1-20190408 4/8/2019 Field Duplicate
<b>Metals</b>										
Aluminum		7390	7429-90-5	mg/Kg-dry	--	26300		31200		37800
Antimony		0.605	7440-36-0	mg/Kg-dry	--	0.686	JQL	0.908	JQL	1.13
Arsenic	0.0027	0.865	7440-38-2	mg/Kg-dry	--	19		19.6		21.3
Barium	300	23.4	7440-39-3	mg/Kg-dry	--	125		156		133
Beryllium	3	0.605	7440-41-7	mg/Kg-dry	--	8.87		10.4		13.8
Cadmium	0.7	0.605	7440-43-9	mg/Kg-dry	--	1.64		1.85		2.78
Calcium	-	568	7440-70-2	mg/Kg-dry	--	259000	JL	261000	JL	258000
Chromium	0.0083	2.69	7440-47-3	mg/Kg-dry	--	299	JL	352	JL	1080
Cobalt	0.4	0.904	7440-48-4	mg/Kg-dry	--	9.8		11.7		19
Copper	60	0.548	7440-50-8	mg/Kg-dry	--	12.7		14.1		19
Iron	1000	2230	7439-89-6	mg/Kg-dry	--	16000		22500		32200
Lead	-	1.79	7439-92-1	mg/Kg-dry	--	9.96		12.1		10.5
Magnesium	-	235	7439-95-4	mg/Kg-dry	--	7590		6500		4890
Manganese	210	44.2	7439-96-5	mg/Kg-dry	--	7660		9070		15000
Nickel	30	6.3	7440-02-0	mg/Kg-dry	--	47.1	JL	46.5	JL	73.1
Potassium	-	151	2023695	mg/Kg-dry	--	1580	JL	2120	JL	1310
Selenium	7	0.167	7782-49-2	mg/Kg-dry	--	4.9		5.31		5.21
Silver	7	0.605	7440-22-4	mg/Kg-dry	--	2.7		3.09		5.05
Sodium	-	96.8	7440-23-5	mg/Kg-dry	--	1200		1460		1190
Zinc	400	4.21	7440-66-6	mg/Kg-dry	--	108	JK	194	JK	153
Mercury	240	0.974	7439-97-6	ug/Kg-dry	--	41.6		75.8		47
Cyanide- Total	0.9	2.45	57-12-5	mg/Kg-dry	--	1.24	JQ	1.18	J	0.93
<b>RAD*</b>										
Ra-226	3,950	0.7	13982-63-3	pCi/g	--	12		13.1		28
Ra-228	1,420	0.92	15262-20-1	pCi/g	--	12.7		12.4		25.7
Th-228	4,820	0.98	14274-82-9	pCi/g	--	13.1		13.9		26.3
Th-230	17,100	0.56	14269-63-7	pCi/g	--	15.7		17		29.4
Th-232	15,300	1.05	7440-29-1	pCi/g	--	13.4		14.1		23.6
U-234	21,300	0.49	13966-29-5	pCi/g	--	75		93		267
U-235	20,800	0.026	15117-96-1	pCi/g	--	3.65		4.2		12.2
U-238	16,800	0.52	7440-61-1	pCi/g	--	78		94		279

Note:

ug/L - microgram per liter, mg/L - milligram per liter ,

pCi/g - picocurie per gram

Highlighted yellow - Above 3x Background or R

U - Analyzed but not detected

Highlighted orange - above lowest SCDM benchmark

J - Analyte detected below Quantitation Limit

H - Biased high

L - Biased low

K - Unknown bias

Q - The reported concentration is less than the sample quantitation limit for the specific analyte in the sample.

\* Rad results compared to 3x background or RL, not 2 standard deviations above the mean



**ATTACHMENT 2**  
**URANIUM AND THORIUM DECAY CHAINS**

## Natural Decay Series: Uranium, Radium, and Thorium

Uranium, radium, and thorium occur in three natural decay series, headed by uranium-238, thorium-232, and uranium-235, respectively. In nature, the radionuclides in these three series are approximately in a state of secular equilibrium, in which the activities of all radionuclides within each series are nearly equal.

Two conditions are necessary for secular equilibrium. First, the parent radionuclide must have a half-life much longer than that of any other radionuclide in the series. Second, a sufficiently long period of time must have elapsed, for example ten half-lives of the decay product having the longest half-life, to allow for ingrowth of the decay products (*see the companion fact sheet on Ionizing Radiation*). Under secular equilibrium, the activity of the parent radionuclide undergoes no appreciable changes during many half-lives of its decay products.

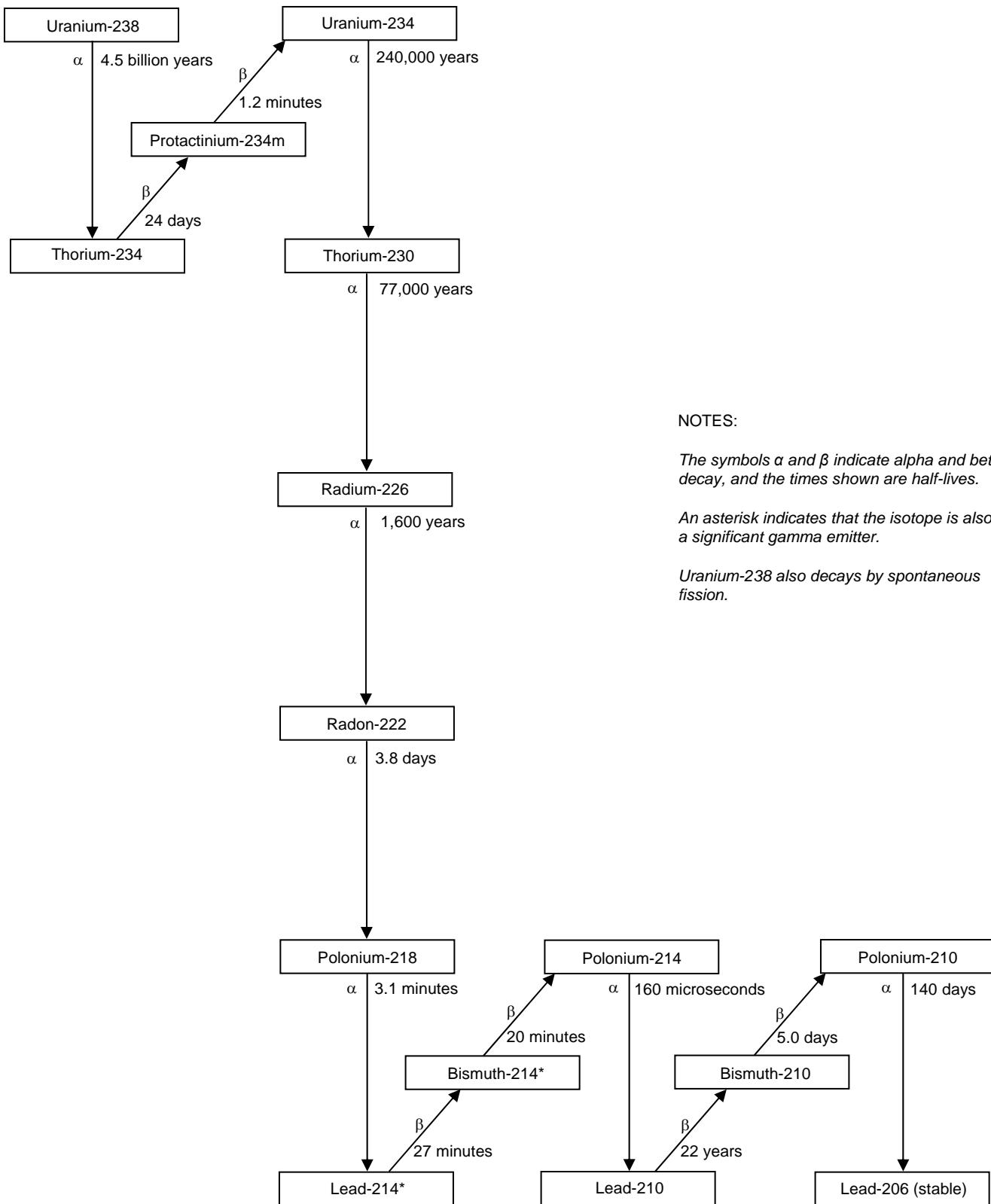
The radionuclides of the uranium-238, thorium-232, and uranium-235 decay series are shown in Figures N.1, N.2, and N.3, along with the major mode of radioactive decay for each. Radioactive decay occurs when an unstable (radioactive) isotope transforms to a more stable isotope, generally by emitting a subatomic particle such as an alpha or beta particle. Radionuclides that give rise to alpha and beta particles are shown in these figures, as are those that emit significant gamma radiation.

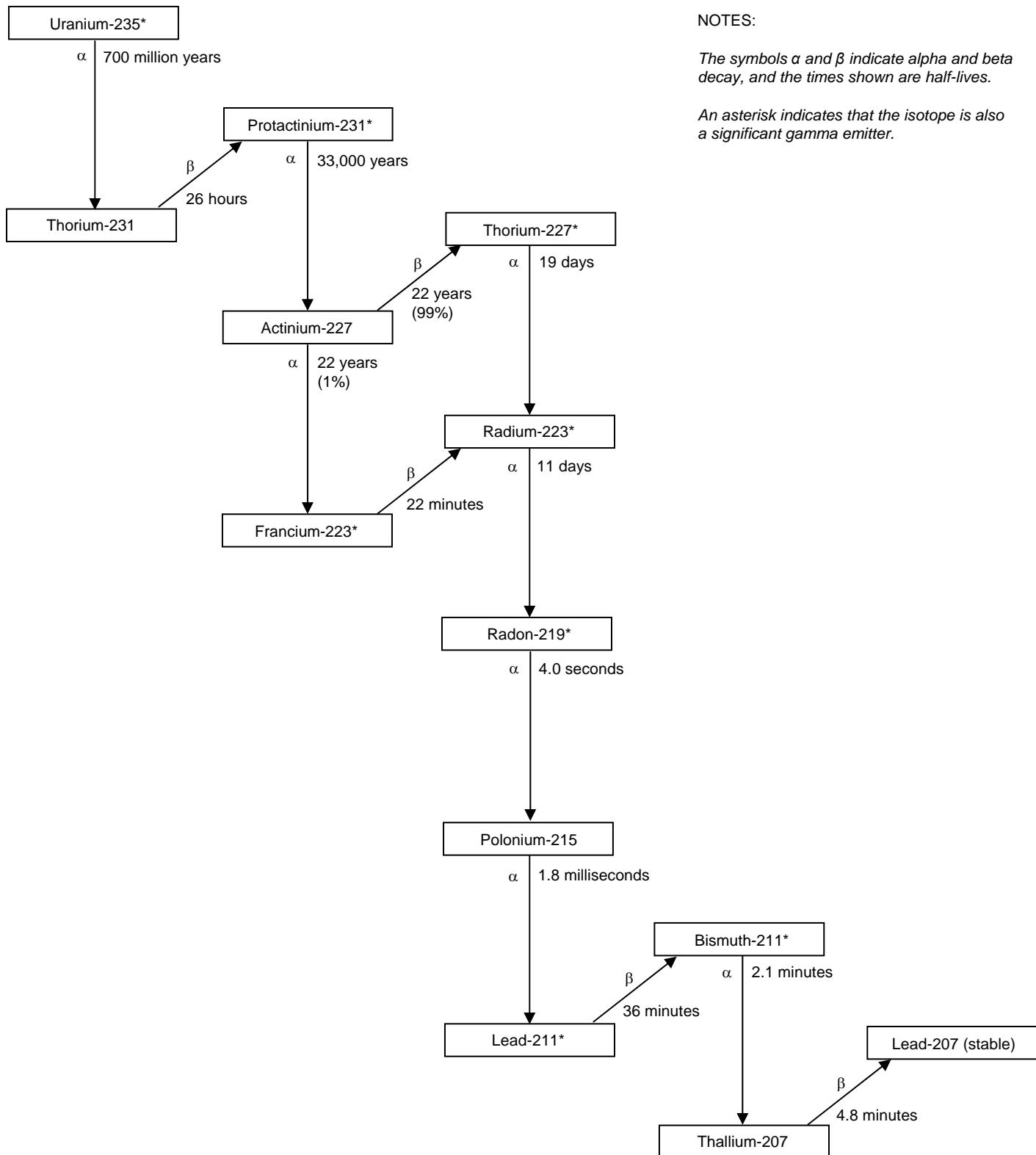
Gamma radiation is not a mode of radioactive decay (such as alpha and beta decay). Rather, it is a mechanism by which excess energy is emitted from certain radionuclides, i.e., as highly energetic electromagnetic radiation emitted from the nucleus of the atom. For simplicity, only significant gamma emissions associated with the major decay modes are shown in Figures N.1 through N.3; that is, radionuclides listed are those for which the radiation dose associated with gamma rays may pose a health concern. The gamma component is not shown for those radionuclides whose gamma emissions do not generally represent a concern.

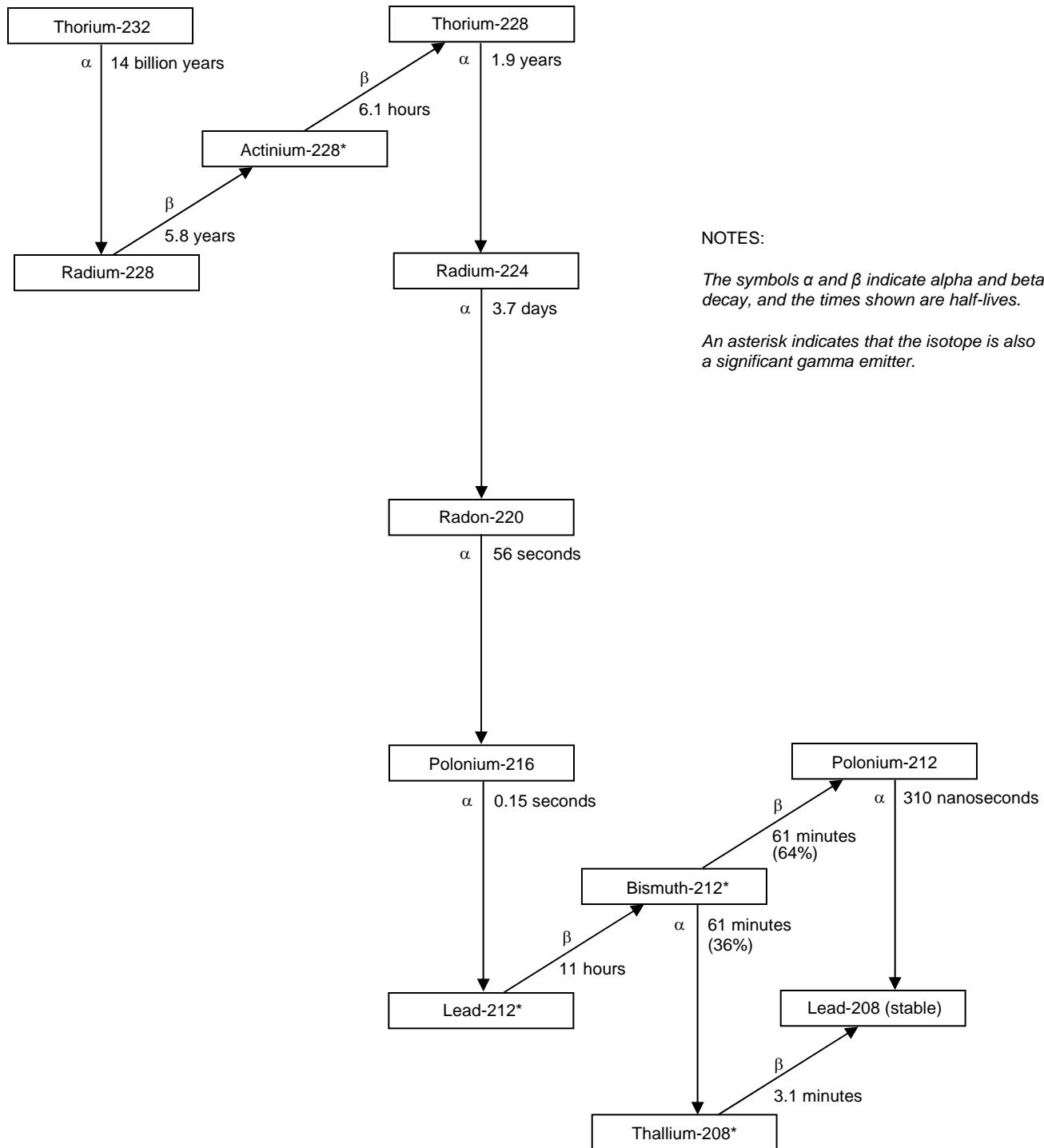
Of the two conditions noted above for secular equilibrium, the first is generally met for the uranium-238, thorium-232 and uranium-235 decay series in naturally occurring ores. While the second condition may not be met for all ores or other deposits of uranium and thorium (given the extremely long half-lives for the radionuclides involved and the geological changes that occur over similar time scales), it is reasonable to assume secular equilibrium for naturally occurring ores to estimate the concentrations of the various daughter radionuclides that accompany the parent. The state of secular equilibrium in natural uranium and thorium ores is significantly altered when they are processed to extract specific radionuclides.

After processing, radionuclides with half-lives less than one year will reestablish equilibrium conditions with their longer-lived parent radionuclides within several years. For this reason, at processing sites what was once a single, long decay series (for example the series for uranium-238) may be present as several smaller decay series headed by the longer-lived decay products of the original series (that is, headed by uranium-238, uranium-234, thorium-230, radium-226, and lead-210 in the case of uranium-238). Each of these sub-series can be considered to represent a new, separate decay series. Understanding the physical and chemical processes associated with materials containing uranium, thorium, and radium is important when addressing associated radiological risks.

In the fact sheets developed for uranium, radium, and thorium, the contributions of radionuclides having half-lives less than one year were included in the risk coefficients. (Each fact sheet identifies which radionuclides are included in these coefficients.) In some situations, it may be necessary to add the radiological risk identified for a given radionuclide to that of its parent radionuclide to properly represent the total risk. For example, the radiological risk for thorium-232 is comprised of the risk for thorium-232 plus the risk for radium-228. Decay series information should be used together with the information in these fact sheets to ensure that the radiological risks associated with uranium, radium, and thorium are properly estimated and represented.

**FIGURE N.1 Natural Decay Series: Uranium-238**

**FIGURE N.2 Natural Decay Series: Uranium-235**

**FIGURE N.3 Natural Decay Series: Thorium-232**

**ATTACHMENT 3**  
**PRG CALCULATOR RISK CALCULATION RESULT**

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000029 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
<a href="#"><i>Secular Equilibrium PRG for U-238</i></a>	<b>7.06E-01</b>	<b>8.35E+01</b>	<b>2.71E-02</b>	<b>2.61E-02</b>

# Site-specific

## Outdoor Worker Individual Contribution PRGs for Soil - Secular Equilibrium

Isotope	Parent	Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Lambda (1/yr)	Halflife (yr)
<b>Secular Equilibrium PRG for U-238</b>								
At-218	U-238	2.00E-04	-	0.00E+00	2.74E-11	0.00E+00	1.46E+07	4.76E-08
Bi-210	U-238	1.00E+00	S	4.55E-10	2.77E-09	3.74E-12	5.05E+01	1.37E-02
Bi-214	U-238	1.00E+00	S	6.18E-11	7.34E-06	1.47E-13	1.83E+04	3.79E-05
Hg-206	U-238	1.90E-08	-	0.00E+00	4.83E-07	0.00E+00	4.47E+04	1.55E-05
Pa-234	U-238	1.60E-03	S	1.20E-12	6.62E-06	9.66E-13	9.06E+02	7.65E-04
Pa-234m	U-238	1.00E+00	-	0.00E+00	9.06E-08	0.00E+00	3.11E+05	2.23E-06
Pb-210	U-238	1.00E+00	S	1.59E-08	1.48E-09	5.99E-10	3.12E-02	2.22E+01
Pb-214	U-238	1.00E+00	S	7.77E-11	9.94E-07	2.21E-13	1.36E+04	5.10E-05
Po-210	U-238	1.00E+00	S	1.45E-08	4.51E-11	1.44E-09	1.83E+00	3.79E-01
Po-214	U-238	1.00E+00	-	0.00E+00	3.85E-10	0.00E+00	1.33E+11	5.21E-12
Po-218	U-238	1.00E+00	-	1.39E-11	6.84E-15	0.00E+00	1.17E+05	5.90E-06
Ra-226	U-238	1.00E+00	S	2.82E-08	2.50E-08	2.95E-10	4.33E-04	1.60E+03
Rn-218	U-238	2.00E-07	-	0.00E+00	3.39E-09	0.00E+00	6.24E+08	1.11E-09
Rn-222	U-238	1.00E+00	-	2.28E-12	1.69E-09	0.00E+00	6.62E+01	1.05E-02
Th-230	U-238	1.00E+00	F	3.41E-08	8.45E-10	7.73E-11	9.19E-06	7.54E+04
Th-234	U-238	1.00E+00	S	3.08E-11	1.77E-08	9.51E-12	1.05E+01	6.60E-02
Tl-206	U-238	1.34E-06	-	0.00E+00	6.11E-09	0.00E+00	8.67E+04	7.99E-06
Tl-210	U-238	2.10E-04	-	0.00E+00	1.34E-05	0.00E+00	2.80E+05	2.47E-06
U-234	U-238	1.00E+00	S	2.78E-08	2.53E-10	5.11E-11	2.82E-06	2.46E+05
U-238	U-238	1.00E+00	S	2.36E-08	1.24E-10	4.66E-11	1.55E-10	4.47E+09

# Site-specific

## Outdoor Worker Individual Contribution PRGs for Soil - Secular Equilibrium

Isotope	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m <sup>3</sup> /kg)	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (mg/kg)
<b>Secular Equilibrium PRG for U-238</b>								
At-218	-	-	-	<b>7.06E-01</b>	<b>8.35E+01</b>	<b>2.71E-02</b>	<b>2.61E-02</b>	-
Bi-210	9.00E-01	1.00E+00	1.36E+09	-	-	3.94E+07	<b>3.94E+07</b>	7.37E-25
Bi-214	8.04E-01	1.00E+00	1.36E+09	4.76E+02	2.66E+04	8.75E+01	<b>7.37E+01</b>	1.10E-13
Bi-214	8.49E-01	1.00E+00	1.36E+09	1.21E+04	1.96E+05	3.12E-02	<b>3.12E-02</b>	7.26E-13
Hg-206	8.20E-01	1.00E+00	1.36E+09	-	-	2.59E+07	<b>2.59E+07</b>	3.46E-22
Pa-234	8.55E-01	1.00E+00	1.36E+09	1.15E+06	6.30E+09	2.15E+01	<b>2.15E+01</b>	2.33E-14
Pa-234m	8.71E-01	1.00E+00	1.36E+09	-	-	2.47E+00	<b>2.47E+00</b>	5.91E-16
Pb-210	9.05E-01	1.00E+00	1.36E+09	2.97E+00	7.61E+02	1.45E+02	<b>2.90E+00</b>	4.51E-09
Pb-214	8.34E-01	1.00E+00	1.36E+09	8.06E+03	1.56E+05	2.35E-01	<b>2.35E-01</b>	1.30E-13
Po-210	8.70E-01	1.00E+00	1.36E+09	1.24E+00	8.33E+02	4.96E+03	<b>1.24E+00</b>	1.80E-10
Po-214	8.69E-01	1.00E+00	1.36E+09	-	-	5.82E+02	<b>5.82E+02</b>	5.37E-24
Po-218	9.00E-01	1.00E+00	1.36E+09	-	8.69E+05	3.16E+07	<b>8.46E+05</b>	4.26E-21
Ra-226	7.27E-01	1.00E+00	1.36E+09	6.04E+00	4.29E+02	1.07E+01	<b>3.83E+00</b>	2.65E-07
Rn-218	8.38E-01	1.00E+00	1.36E+09	-	-	3.43E+08	<b>3.43E+08</b>	1.97E-27
Rn-222	8.58E-01	1.00E+00	1.36E+09	-	5.30E+06	1.34E+02	<b>1.34E+02</b>	4.86E-14
Th-230	9.62E-01	1.00E+00	1.36E+09	2.30E+01	3.55E+02	2.39E+02	<b>1.98E+01</b>	2.45E-06
Th-234	8.04E-01	1.00E+00	1.36E+09	1.87E+02	3.93E+05	1.36E+01	<b>1.27E+01</b>	3.40E-12
Tl-206	8.23E-01	1.00E+00	1.36E+09	-	-	2.89E+07	<b>2.89E+07</b>	1.59E-22
Tl-210	8.54E-01	1.00E+00	1.36E+09	-	-	8.09E+01	<b>8.09E+01</b>	1.80E-17
U-234	1.00E+00	1.00E+00	1.36E+09	3.48E+01	4.34E+02	7.68E+02	<b>3.09E+01</b>	5.20E-06
U-238	1.00E+00	1.00E+00	1.36E+09	3.81E+01	5.11E+02	1.57E+03	<b>3.47E+01</b>	8.58E-02

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for U-238	6.90E-05	5.83E-07	1.80E-03	1.87E-03
*Total Risk	6.90E-05	5.83E-07	1.80E-03	1.87E-03

# Site-specific

## Outdoor Worker Individual Risk Contributions for Soil - Secular Equilibrium

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Lambda (1/yr)	Halflife (yr)	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
<b>*Secular Equilibrium Risk for U-238</b>		-	-	-	-	-	-	-
At-218	-	0.00E+00	2.74E-11	0.00E+00	1.46E+07	4.76E-08	9.00E-01	1.00E+00
Bi-210	S	4.55E-10	2.77E-09	3.74E-12	5.05E+01	1.37E-02	8.04E-01	1.00E+00
Bi-214	S	6.18E-11	7.34E-06	1.47E-13	1.83E+04	3.79E-05	8.49E-01	1.00E+00
Hg-206	-	0.00E+00	4.83E-07	0.00E+00	4.47E+04	1.55E-05	8.20E-01	1.00E+00
Pa-234	S	1.20E-12	6.62E-06	9.66E-13	9.06E+02	7.65E-04	8.55E-01	1.00E+00
Pa-234m	-	0.00E+00	9.06E-08	0.00E+00	3.11E+05	2.23E-06	8.71E-01	1.00E+00
Pb-210	S	1.59E-08	1.48E-09	5.99E-10	3.12E-02	2.22E+01	9.05E-01	1.00E+00
Pb-214	S	7.77E-11	9.94E-07	2.21E-13	1.36E+04	5.10E-05	8.34E-01	1.00E+00
Po-210	S	1.45E-08	4.51E-11	1.44E-09	1.83E+00	3.79E-01	8.70E-01	1.00E+00
Po-214	-	0.00E+00	3.85E-10	0.00E+00	1.33E+11	5.21E-12	8.69E-01	1.00E+00
Po-218	-	1.39E-11	6.84E-15	0.00E+00	1.17E+05	5.90E-06	9.00E-01	1.00E+00
Ra-226	S	2.82E-08	2.50E-08	2.95E-10	4.33E-04	1.60E+03	7.27E-01	1.00E+00
Rn-218	-	0.00E+00	3.39E-09	0.00E+00	6.24E+08	1.11E-09	8.38E-01	1.00E+00
Rn-222	-	2.28E-12	1.69E-09	0.00E+00	6.62E+01	1.05E-02	8.58E-01	1.00E+00
Th-230	F	3.41E-08	8.45E-10	7.73E-11	9.19E-06	7.54E+04	9.62E-01	1.00E+00
Th-234	S	3.08E-11	1.77E-08	9.51E-12	1.05E+01	6.60E-02	8.04E-01	1.00E+00
Tl-206	-	0.00E+00	6.11E-09	0.00E+00	8.67E+04	7.99E-06	8.23E-01	1.00E+00
Tl-210	-	0.00E+00	1.34E-05	0.00E+00	2.80E+05	2.47E-06	8.54E-01	1.00E+00
U-234	S	2.78E-08	2.53E-10	5.11E-11	2.82E-06	2.46E+05	1.00E+00	1.00E+00
U-238	S	2.36E-08	1.24E-10	4.66E-11	1.55E-10	4.47E+09	1.00E+00	1.00E+00

## Outdoor Worker Individual Risk Contributions for Soil - Secular Equilibrium

Isotope	Infinite Soil Volume Concentration (pCi/g)	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
<b>*Secular Equilibrium Risk for U-238</b>	-	-	-	-	<b>6.90E-05</b>	<b>5.83E-07</b>	<b>1.80E-03</b>	<b>1.87E-03</b>
At-218	48.7	2.74E+04	4.03E+00	2.25E+02	0.00E+00	0.00E+00	1.24E-12	<b>1.24E-12</b>
Bi-210	48.7	2.74E+04	4.03E+00	2.01E+02	1.02E-07	1.83E-09	5.56E-07	<b>6.61E-07</b>
Bi-214	48.7	2.74E+04	4.03E+00	2.12E+02	4.03E-09	2.49E-10	1.56E-03	<b>1.56E-03</b>
Hg-206	48.7	2.74E+04	4.03E+00	2.05E+02	0.00E+00	0.00E+00	1.88E-12	<b>1.88E-12</b>
Pa-234	48.7	2.74E+04	4.03E+00	2.14E+02	4.23E-11	7.73E-15	2.27E-06	<b>2.27E-06</b>
Pa-234m	48.7	2.74E+04	4.03E+00	2.18E+02	0.00E+00	0.00E+00	1.97E-05	<b>1.97E-05</b>
Pb-210	48.7	2.74E+04	4.03E+00	2.26E+02	1.64E-05	6.40E-08	3.36E-07	<b>1.68E-05</b>
Pb-214	48.7	2.74E+04	4.03E+00	2.09E+02	6.04E-09	3.13E-10	2.07E-04	<b>2.07E-04</b>
Po-210	48.7	2.74E+04	4.03E+00	2.18E+02	3.93E-05	5.85E-08	9.81E-09	<b>3.94E-05</b>
Po-214	48.7	2.74E+04	4.03E+00	2.17E+02	0.00E+00	0.00E+00	8.37E-08	<b>8.37E-08</b>
Po-218	48.7	2.74E+04	4.03E+00	2.25E+02	0.00E+00	5.60E-11	1.54E-12	<b>5.76E-11</b>
Ra-226	48.7	2.74E+04	4.03E+00	1.82E+02	8.07E-06	1.13E-07	4.54E-06	<b>1.27E-05</b>
Rn-218	48.7	2.74E+04	4.03E+00	2.10E+02	0.00E+00	0.00E+00	1.42E-13	<b>1.42E-13</b>
Rn-222	48.7	2.74E+04	4.03E+00	2.15E+02	0.00E+00	9.19E-12	3.63E-07	<b>3.63E-07</b>
Th-230	48.7	2.74E+04	4.03E+00	2.41E+02	2.12E-06	1.37E-07	2.03E-07	<b>2.46E-06</b>
Th-234	48.7	2.74E+04	4.03E+00	2.01E+02	2.60E-07	1.24E-10	3.57E-06	<b>3.83E-06</b>
Tl-206	48.7	2.74E+04	4.03E+00	2.06E+02	0.00E+00	0.00E+00	1.68E-12	<b>1.68E-12</b>
Tl-210	48.7	2.74E+04	4.03E+00	2.14E+02	0.00E+00	0.00E+00	6.02E-07	<b>6.02E-07</b>
U-234	48.7	2.74E+04	4.03E+00	2.50E+02	1.40E-06	1.12E-07	6.34E-08	<b>1.57E-06</b>
U-238	48.7	2.74E+04	4.03E+00	2.50E+02	1.28E-06	9.53E-08	3.10E-08	<b>1.40E-06</b>

The total risk for just U-238 through Pa-234 =  $2.27\text{E-}06 + 1.97\text{E-}05 + 3.83\text{E-}06 + 1.57\text{E-}06 + 1.40\text{E-}06 = 2.88\text{E-}05$

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000029 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific

## Outdoor Worker PRGs for Soil - No secular equilibrium, no progeny (with decay)

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Lambda (1/yr)	Halflife (yr)	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m <sup>3</sup> /kg)	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (mg/kg)
Th-230	F	3.41E-08	8.45E-10	7.73E-11	9.19E-06	7.54E+04	9.62E-01	1.00E+00	1.36E+09	2.30E+01	3.55E+02	2.39E+02	1.98E+01	9.61E-04

# Site-specific

## Outdoor Worker Risk for Soil - No secular equilibrium, no progeny (with decay)

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Lambda (1/yr)	Halflife (yr)	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
Th-230	F	3.41E-08	8.45E-10	7.73E-11	9.19E-06	7.54E+04	9.62E-01	1.00E+00
*Total Risk		-	-	-	-	-	-	-

Isotope	Infinite Soil Volume Concentration (pCi/g)		Ingestion CDI (pCi)		External Exposure CDI (pCi)		Ingestion Risk		Inhalation Risk		External Exposure Risk		Total Risk
Th-230	72	4.05E+04	5.96E+00	3.56E+02	3.13E-06	2.03E-07	3.01E-07	3.64E-06					
*Total Risk	-	-	-	-	3.13E-06	2.03E-07	3.01E-07	3.64E-06					

The total risk for Th-230 = 3.64E-06

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000029 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
<i>Secular Equilibrium PRG for Ra-226</i>	<i>7.62E-01</i>	<i>2.04E+02</i>	<i>2.75E-02</i>	<i>2.65E-02</i>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	1.16E-04	4.31E-07	3.21E-03	3.32E-03
*Total Risk	1.16E-04	4.31E-07	3.21E-03	3.32E-03

The total risk for Ra-226 through Pb-210 = 3.23E-03

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000029 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
<i>Secular Equilibrium PRG for Th-232</i>	<i>1.94E+00</i>	<i>5.22E+01</i>	<i>1.97E-02</i>	<i>1.95E-02</i>
<i>Secular Equilibrium PRG for U-235</i>	<i>3.23E+00</i>	<i>3.84E+01</i>	<i>1.05E-01</i>	<i>1.01E-01</i>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Th-232	9.60E-06	3.56E-07	9.45E-04	9.55E-04
*Secular Equilibrium Risk for U-235	8.32E-07	7.00E-08	2.57E-05	2.66E-05
*Total Risk	1.04E-05	4.26E-07	9.71E-04	9.82E-04

The total risk for the full U-235 decay chain = 2.66E-05. The total risk for the Th-232 decay chain = 9.55E-04.

The total risk for the full U-238, U-235, and Th-232 decay chains is thus:

$$\begin{aligned}
 & 2.88\text{E-}05 + \\
 & 3.64\text{E-}06 + \\
 & 3.23\text{E-}03 + \\
 & 2.66\text{E-}05 + \\
 & 9.55\text{E-}04 = 4.33\text{E-}03
 \end{aligned}$$

**ATTACHMENT 4**  
**COVER THICKNESS CALCULATION RESULTS FOR RADON FLUX**

**Attachment 4**  
**Cover Thickness Calculation Results for Radon Flux**  
**Fansteel Metals/ FMRI**  
**Muskogee, Muskogee County, Oklahoma**

	Type of Material	<sup>1</sup> Thickness of Layer (cm) (x)	<sup>2</sup> Porosity of Material (Unitless) (n)	<sup>3</sup> Density of Material (g/cm <sup>3</sup> ) ( $\rho$ )	<sup>3</sup> Radon Emanation Coefficient (Unitless) (E)	<sup>3</sup> Radon Decay Constant (1/s) ( $\lambda$ )	<sup>3</sup> Long-term Average Moisture Content (Dry weight percentage) (w)	<sup>3</sup> Specific Gravity of Soils (Unitless) (G)
Contaminated Soils	Native soil	130	0.305660377	1.84	0.35	2.10E-06	10	2.65
Cover layer	Native soil	<b>23</b>	0.305660377	1.84	0.35	2.10E-06	10	2.65
	<b>Specific Activity of Ra-226 (pCi/g) (R)</b>	<sup>2</sup> Moisture saturation fractions (Unitless) (m)	<sup>2</sup> Radon Diffusion Coefficients (cm <sup>2</sup> /s) (D)	<sup>2</sup> Inverse relaxation length (1/cm) (b)	<sup>2</sup> Interface constants (cm <sup>2</sup> /s) (a)	<sup>3</sup> Equilibrium distribution Coffecient of Radon in Water and Air (pCi/cm <sup>3</sup> ) (k)	<sup>2</sup> Radon Flux from the bare contaminated soil (pCi/m <sup>2</sup> -s) (J <sub>t</sub> )	<sup>2</sup> Radon Flux from the Cover (pCi/m <sup>2</sup> -s) (J <sub>c</sub> )
Contaminated Soils	<b>44</b>	0.6020	5.75E-03	0.0191	0.0002	0.2600	31	
Cover Layer	0.5	0.6020	5.75E-03	0.0191	0.0002	0.2600	0.1	<b>19.9</b>
							NRC Radon Flux Limit:	20

<sup>1</sup>Thickness of cover layer was determined by trial and error in order to determine the maximum thickness with a Radon Flux result less than or equal to the NRC limit of 20 pCi/m<sup>2</sup>-s. A cover thickness of 23 centimeters is equivalent to approximately 0.75 feet. The contaminated soil thickness of 130 centimeters = 51 inches = 4.25 feet. The radon flux calculated result remains the same (19.9 pCi/m<sup>2</sup>-s) beyond a thickness of 130 centimeters.

<sup>2</sup>Value calculated per NRC Regulatory Guide 3.64 formulas noted below. The NRC Regulatory Guide 3.64 formulas were designed with uranium mill tailings in mind; therefore, the subscripts 't' and 'c' in the formulas below refer to 'tailings' and 'cover', respectively. In this case, the formulas and terms with the 't' subscript are used for 'Contaminated Soils' and the formulas and terms with the 'c' subscript are used for 'Cover layer'.

<sup>3</sup>Value obtained from NRC Regulatory Guide 3.64.

**NRC Regulatory Guide 3.64 Radon Flux Formulas:**

$$J_t = 10^4 * R * \rho * E * \sqrt{(\lambda * D)} * \text{hyperbolic tangent of } (x * \sqrt{\lambda/D})$$

$$J_c = \frac{2 * J_t * e^{-b} * c}{1 + \sqrt{a_t/a_c}}$$

$$D = 0.07 * e^{-4 * (m - (m * n^2) + (m^5))}$$

$$m = \frac{10^{-2} * \rho * w}{n * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$n = 1 - \frac{\rho}{G * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$b = \sqrt{\lambda/D}$$

$$a = n^2 * D * (1 - ((1-k) * m))^2$$



**Attachment 4 (Continued)**  
**Cover Thickness Calculation Results for Radon Flux**  
**Fansteel Metals/ FMRI**  
**Muskogee, Muskogee County, Oklahoma**

	Type of Material	<sup>1</sup> Thickness of Layer (cm) (x)	<sup>2</sup> Porosity of Material (Unitless) (n)	<sup>3</sup> Density of Material (g/cm <sup>3</sup> ) (ρ)	<sup>3</sup> Radon Emanation Coefficient (Unitless) (E)	<sup>3</sup> Radon Decay Constant (1/s) (λ)	<sup>3</sup> Long-term Average Moisture Content (Dry weight percentage) (w)	<sup>3</sup> Specific Gravity of Soils (Unitless) (G)
Contaminated Soils	Native soil	130	0.305660377	1.84	0.35	2.10E-06	10	2.65
Cover layer	Native soil	40	0.305660377	1.84	0.35	2.10E-06	10	2.65
	<b>Specific Activity of Ra-226 (pCi/g) (R)</b>	<sup>2</sup> Moisture saturation fractions (Unitless) (m)	<sup>2</sup> Radon Diffusion Coefficients (cm <sup>2</sup> /s) (D)	<sup>2</sup> Inverse relaxation length (1/cm) (b)	<sup>2</sup> Interface constants (cm <sup>2</sup> /s) (a)	<sup>3</sup> Equilibrium distribution Coffecient of Radon in Water and Air (pCi/cm <sup>3</sup> ) (k)	<sup>2</sup> Radon Flux from the bare contaminated soil (pCi/m <sup>2</sup> -s) (J <sub>t</sub> )	<sup>2</sup> Radon Flux from the Cover (pCi/m <sup>2</sup> -s) (J <sub>c</sub> )
Contaminated Soils	60	0.6020	5.75E-03	0.0191	0.0002	0.2600	42	
Cover Layer	0.5	0.6020	5.75E-03	0.0191	0.0002	0.2600	0.2	19.7
							NRC Radon Flux Limit:	20

<sup>1</sup>Thickness of cover layer was determined by trial and error in order to determine the maximum thickness with a Radon Flux result less than or equal to the NRC limit of 20 pCi/m<sup>2</sup>-s. A cover thickness of 40 centimeters is equivalent to 1.31 feet. The contaminated soil thickness of 130 centimeters = 51 inches = 4.25 feet. The radon flux calculated result remains the same (19.7 pCi/m<sup>2</sup>-s) beyond a thickness of 130 centimeters.

<sup>2</sup>Value calculated per NRC Regulatory Guide 3.64 formulas noted below. The NRC Regulatory Guide 3.64 formulas were designed with uranium mill tailings in mind; therefore, the subscripts 't' and 'c' in the formulas below refer to 'tailings' and 'cover', respectively. In this case, the formulas and terms with the 't' subscript are used for 'Contaminated Soils' and the formulas and terms with the 'c' subscript are used for 'Cover layer'.

<sup>3</sup>Value obtained from NRC Regulatory Guide 3.64.

**NRC Regulatory Guide 3.64 Radon Flux Formulas:**

$$J_t = 10^4 * R * \rho * E * V(\lambda * D) * \text{hyperbolic tangent of } (x * V(\lambda/D))$$

$$J_c = \frac{2 * J_t * e^{-b} * x}{1 + V(a_t/a_c)}$$

$$D = 0.07 * e^{-4 * (m - (m * n^2) + (m^5))}$$

$$m = \frac{10^{-2} * \rho * w}{n * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$n = 1 - \frac{\rho}{G * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$b = V(\lambda/D)$$

$$a = n^2 * D * (1 - ((1 - k) * m))^2$$



**Attachment 4 (Continued)**  
**Cover Thickness Calculation Results for Radon Flux**  
**Fansteel Metals/ FMRI**  
**Muskogee, Muskogee County, Oklahoma**

	Type of Material	<sup>1</sup> Thickness of Layer (cm) (x)	<sup>2</sup> Porosity of Material (Unitless) (n)	<sup>3</sup> Density of Material (g/cm <sup>3</sup> ) (ρ)	<sup>3</sup> Radon Emanation Coefficient (Unitless) (E)	<sup>3</sup> Radon Decay Constant (1/s) (λ)	<sup>3</sup> Long-term Average Moisture Content (Dry weight percentage) (w)	<sup>3</sup> Specific Gravity of Soils (Unitless) (G)
Contaminated Soils	Native soil	130	0.305660377	1.84	0.35	2.10E-06	10	2.65
Cover layer	Native soil	60	0.305660377	1.84	0.35	2.10E-06	10	2.65
	<b>Specific Activity of Ra-226 (pCi/g) (R)</b>	<sup>2</sup> Moisture saturation fractions (Unitless) (m)	<sup>2</sup> Radon Diffusion Coefficients (cm <sup>2</sup> /s) (D)	<sup>2</sup> Inverse relaxation length (1/cm) (b)	<sup>2</sup> Interface constants (cm <sup>2</sup> /s) (a)	<sup>3</sup> Equilibrium distribution Coffecient of Radon in Water and Air (pCi/cm <sup>3</sup> ) (k)	<sup>2</sup> Radon Flux from the bare contaminated soil (pCi/m <sup>2</sup> -s) (J <sub>t</sub> )	<sup>2</sup> Radon Flux from the Cover (pCi/m <sup>2</sup> -s) (J <sub>c</sub> )
Contaminated Soils	88	0.6020	5.75E-03	0.0191	0.0002	0.2600	61	
Cover Layer	0.5	0.6020	5.75E-03	0.0191	0.0002	0.2600	0.3	19.8
							NRC Radon Flux Limit:	20

<sup>1</sup>Thickness of cover layer was determined by trial and error in order to determine the maximum thickness with a Radon Flux result less than or equal to the NRC limit of 20 pCi/m<sup>2</sup>-s. A cover thickness of 60 centimeters is equivalent to 23.6 inches or 2 feet. The contaminated soil thickness of 130 centimeters = 51 inches = 4.25 feet. The radon flux calculated result remains the same (19.8 pCi/m<sup>2</sup>-s) beyond a thickness of 130 centimeters.

<sup>2</sup>Value calculated per NRC Regulatory Guide 3.64 formulas noted below. The NRC Regulatory Guide 3.64 formulas were designed with uranium mill tailings in mind; therefore, the subscripts 't' and 'c' in the formulas below refer to 'tailings' and 'cover', respectively. In this case, the formulas and terms with the 't' subscript are used for 'Contaminated Soils' and the formulas and terms with the 'c' subscript are used for 'Cover layer'.

<sup>3</sup>Value obtained from NRC Regulatory Guide 3.64.

**NRC Regulatory Guide 3.64 Radon Flux Formulas:**

$$J_t = 10^4 * R * \rho * E * V(\lambda * D) * \text{hyperbolic tangent of } (x * V(\lambda/D))$$

$$J_c = \frac{2 * J_t * e^{-b} * x}{1 + V(a_t/a_c)}$$

$$D = 0.07 * e^{-4 * (m - (m * n^2) + (m^5))}$$

$$m = \frac{10^{-2} * \rho * w}{n * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$n = 1 - \frac{\rho}{G * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$b = V(\lambda/D)$$

$$a = n^2 * D * (1 - ((1 - k) * m))^2$$



**Attachment 4 (Continued)**  
**Cover Thickness Calculation Results for Radon Flux**  
**Fansteel Metals/ FMRI**  
**Muskogee, Muskogee County, Oklahoma**

	Type of Material	<sup>1</sup> Thickness of Layer (cm) (x)	<sup>2</sup> Porosity of Material (Unitless) (n)	<sup>3</sup> Density of Material (g/cm <sup>3</sup> ) (ρ)	<sup>3</sup> Radon Emanation Coefficient (Unitless) (E)	<sup>3</sup> Radon Decay Constant (1/s) (λ)	<sup>3</sup> Long-term Average Moisture Content (Dry weight percentage) (w)	<sup>3</sup> Specific Gravity of Soils (Unitless) (G)
Contaminated Soils	Native soil	130	0.305660377	1.84	0.35	2.10E-06	10	2.65
Cover layer	Native soil	<b>67</b>	0.305660377	1.84	0.35	2.10E-06	10	2.65
	<b>Specific Activity of Ra-226 (pCi/g) (R)</b>	<sup>2</sup> Moisture saturation fractions (Unitless) (m)	<sup>2</sup> Radon Diffusion Coefficients (cm <sup>2</sup> /s) (D)	<sup>2</sup> Inverse relaxation length (1/cm) (b)	<sup>2</sup> Interface constants (cm <sup>2</sup> /s) (a)	<sup>3</sup> Equilibrium distribution coefficient of Radon in Water and Air (pCi/cm <sup>3</sup> ) (k)	<sup>2</sup> Radon Flux from the bare contaminated soil (pCi/m <sup>2</sup> -s) (J <sub>t</sub> )	<sup>2</sup> Radon Flux from the Cover (pCi/m <sup>2</sup> -s) (J <sub>c</sub> )
Contaminated Soils	<b>100</b>	0.6020	5.75E-03	0.0191	0.0002	0.2600	70	
Cover Layer	0.5	0.6020	5.75E-03	0.0191	0.0002	0.2600	0.3	<b>19.7</b>
							NRC Radon Flux Limit:	20

<sup>1</sup>Thickness of cover layer was determined by trial and error in order to determine the maximum thickness with a Radon Flux result less than or equal to the NRC limit of 20 pCi/m<sup>2</sup>-s. A cover thickness of 67 centimeters is equivalent to approximately 2.20 feet. The contaminated soil thickness of 130 centimeters = 51 inches = 4.25 feet. The radon flux calculated result remains the same (19.7 pCi/m<sup>2</sup>-s) beyond a thickness of 130 centimeters.

<sup>2</sup>Value calculated per NRC Regulatory Guide 3.64 formulas noted below. The NRC Regulatory Guide 3.64 formulas were designed with uranium mill tailings in mind; therefore, the subscripts 't' and 'c' in the formulas below refer to 'tailings' and 'cover', respectively. In this case, the formulas and terms with the 't' subscript are used for 'Contaminated Soils' and the formulas and terms with the 'c' subscript are used for 'Cover layer'.

<sup>3</sup>Value obtained from NRC Regulatory Guide 3.64.

**NRC Regulatory Guide 3.64 Radon Flux Formulas:**

$$J_t = 10^4 * R * \rho * E * \sqrt{\lambda * D} * \text{hyperbolic tangent of } (x * \sqrt{\lambda/D})$$

$$J_c = \frac{2 * J_t * e^{-b} * x}{1 + \sqrt{a_t/a_c}}$$

$$D = 0.07 * e^{-4 * (m - (m * n^2) + (m^5))}$$

$$m = \frac{10^{-2} * \rho * w}{n * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$n = 1 - \frac{\rho}{G * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$b = \sqrt{\lambda/D}$$

$$a = n^2 * D * (1 - ((1 - k) * m))^2$$



**Attachment 4 (Continued)**  
**Cover Thickness Calculation Results for Radon Flux**  
**Fansteel Metals/ FMRI**  
**Muskogee, Muskogee County, Oklahoma**

	Type of Material	<sup>1</sup> Thickness of Layer (cm) (x)	<sup>2</sup> Porosity of Material (Unitless) (n)	<sup>3</sup> Density of Material (g/cm <sup>3</sup> ) (ρ)	<sup>3</sup> Radon Emanation Coefficient (Unitless) (E)	<sup>3</sup> Radon Decay Constant (1/s) (λ)	<sup>3</sup> Long-term Average Moisture Content (Dry weight percentage) (w)	<sup>3</sup> Specific Gravity of Soils (Unitless) (G)
Contaminated Soils	Native soil	130	0.305660377	1.84	0.35	2.10E-06	10	2.65
Cover layer	Native soil	78	0.305660377	1.84	0.35	2.10E-06	10	2.65
	<b>Specific Activity of Ra-226 (pCi/g) (R)</b>	<sup>2</sup> Moisture saturation fractions (Unitless) (m)	<sup>2</sup> Radon Diffusion Coefficients (cm <sup>2</sup> /s) (D)	<sup>2</sup> Inverse relaxation length (1/cm) (b)	<sup>2</sup> Interface constants (cm <sup>2</sup> /s) (a)	<sup>3</sup> Equilibrium distribution Coffecient of Radon in Water and Air (pCi/cm <sup>3</sup> ) (k)	<sup>2</sup> Radon Flux from the bare contaminated soil (pCi/m <sup>2</sup> -s) (J <sub>t</sub> )	<sup>2</sup> Radon Flux from the Cover (pCi/m <sup>2</sup> -s) (J <sub>c</sub> )
Contaminated Soils	125	0.6020	5.75E-03	0.0191	0.0002	0.2600	87	
Cover Layer	0.5	0.6020	5.75E-03	0.0191	0.0002	0.2600	0.3	<b>20.0</b>
							NRC Radon Flux Limit:	20

<sup>1</sup>Thickness of cover layer was determined by trial and error in order to determine the maximum thickness with a Radon Flux result less than or equal to the NRC limit of 20 pCi/m<sup>2</sup>-s. A cover thickness of 78 centimeters is equivalent to 2.56 feet. The contaminated soil thickness of 130 centimeters = 51 inches = 4.25 feet. The radon flux calculated result remains the same (20.0 pCi/m<sup>2</sup>-s) beyond a thickness of 130 centimeters.

<sup>2</sup>Value calculated per NRC Regulatory Guide 3.64 formulas noted below. The NRC Regulatory Guide 3.64 formulas were designed with uranium mill tailings in mind; therefore, the subscripts 't' and 'c' in the formulas below refer to 'tailings' and 'cover', respectively. In this case, the formulas and terms with the 't' subscript are used for 'Contaminated Soils' and the formulas and terms with the 'c' subscript are used for 'Cover layer'.

<sup>3</sup>Value obtained from NRC Regulatory Guide 3.64.

**NRC Regulatory Guide 3.64 Radon Flux Formulas:**

$$J_t = 10^4 * R * \rho * E * \sqrt{(\lambda * D)} * \text{hyperbolic tangent of } (x * \sqrt{\lambda/D})$$

$$J_c = \frac{2 * J_t * e^{-b} * x_c}{1 + \sqrt{a_t/a_c}}$$

$$D = 0.07 * e^{-4 * (m - (m * n^2) + (m^5))}$$

$$m = \frac{10^{-2} * \rho * w}{n * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$n = 1 - \frac{\rho}{G * \rho_w}; \rho_w \text{ is the mass density of water} = 1 \text{ g/cm}^3$$

$$b = \sqrt{\lambda/D}$$

$$a = n^2 * D * (1 - ((1 - k) * m))^2$$



**ATTACHMENT 5**

**RESRAD RADIUM BENCHMARK DOSE CALCULATION RESULT**

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Dose Conversion Factor (and Related) Parameter Summary

Dose Library: DOE STD-1196-2011 (Reference Person)

Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
A-1	DCF's for external ground radiation, (mrem/yr) / (pCi/g)			
A-1	At-218 (Source: DCFPAK3.02)	5.567E-05	5.567E-05	DCF1( 1)
A-1	Bi-210 (Source: DCFPAK3.02)	5.473E-03	5.473E-03	DCF1( 2)
A-1	Bi-214 (Source: DCFPAK3.02)	9.135E+00	9.135E+00	DCF1( 3)
A-1	Hg-206 (Source: DCFPAK3.02)	6.127E-01	6.127E-01	DCF1( 4)
A-1	Pb-210 (Source: DCFPAK3.02)	2.092E-03	2.092E-03	DCF1( 5)
A-1	Pb-214 (Source: DCFPAK3.02)	1.257E+00	1.257E+00	DCF1( 6)
A-1	Po-210 (Source: DCFPAK3.02)	5.641E-05	5.641E-05	DCF1( 7)
A-1	Po-214 (Source: DCFPAK3.02)	4.801E-04	4.801E-04	DCF1( 8)
A-1	Po-218 (Source: DCFPAK3.02)	9.228E-09	9.228E-09	DCF1( 9)
A-1	Ra-226 (Source: DCFPAK3.02)	3.176E-02	3.176E-02	DCF1( 10)
A-1	Rn-218 (Source: DCFPAK3.02)	4.259E-03	4.259E-03	DCF1( 11)
A-1	Rn-222 (Source: DCFPAK3.02)	2.130E-03	2.130E-03	DCF1( 12)
A-1	Tl-206 (Source: DCFPAK3.02)	1.278E-02	1.278E-02	DCF1( 13)
A-1	Tl-210 (Source: DCFPAK3.02)	1.677E+01	1.677E+01	DCF1( 14)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Pb-210+D	2.285E-02	2.231E-02	DCF2( 1)
B-1	Pb-210+D1	2.284E-02	2.231E-02	DCF2( 2)
B-1	Po-210	1.732E-02	1.732E-02	DCF2( 3)
B-1	Ra-226+D	3.823E-02	3.811E-02	DCF2( 4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Pb-210+D	3.781E-03	3.774E-03	DCF3( 1)
D-1	Pb-210+D1	3.781E-03	3.774E-03	DCF3( 2)
D-1	Po-210	6.475E-03	6.475E-03	DCF3( 3)
D-1	Ra-226+D	1.677E-03	1.676E-03	DCF3( 4)
D-34	Food transfer factors:			
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF( 1,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF( 1,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF( 1,3)
D-34				
D-34	Pb-210+D1 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF( 2,1)
D-34	Pb-210+D1 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF( 2,2)
D-34	Pb-210+D1 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF( 2,3)
D-34				
D-34	Po-210 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF( 3,1)
D-34	Po-210 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF( 3,2)
D-34	Po-210 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.400E-04	3.400E-04	RTF( 3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF( 4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF( 4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF( 4,3)
D-34				
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC( 1,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC( 1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: DOE STD-1196-2011 (Reference Person)

Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
D-5	Pb-210+D1 , fish	3.000E+02	3.000E+02	BIOFAC( 2,1)
D-5	Pb-210+D1 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC( 2,2)
D-5				
D-5	Po-210 , fish	1.000E+02	1.000E+02	BIOFAC( 3,1)
D-5	Po-210 , crustacea and mollusks	2.000E+04	2.000E+04	BIOFAC( 3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC( 4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC( 4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See EFTG table in Ground Pathway of Detailed Report.

\*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T( 2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T( 3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T( 4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T( 5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T( 6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T( 7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T( 8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T( 9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ra-226	5.000E+00	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1( 4)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm***3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm***3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m***3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm***3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m***3/yr)	not used	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC( 4)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU( 4,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS( 4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.165E-02	ALEACH( 4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.217E-02	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R016	Distribution coefficients for daughter Po-210				
R016	Contaminated zone (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCC( 3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+01	---	DCNUCU( 3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+01	---	DCNUCS( 3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.176E-01	ALEACH( 3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 3)
R017	Inhalation rate (m**3/yr)	1.350E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.055E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	2.250E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSLF
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Ra-226	5.000E+00
Thickness:	0.15 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr  
Basic Radiation Dose Limit = 2.500E+01 mrem/yr  
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	8.409E+00	8.130E+00	7.600E+00	5.992E+00	2.993E+00	2.025E-01	0.000E+00	0.000E+00
M(t):	3.363E-01	3.252E-01	3.040E-01	2.397E-01	1.197E-01	8.099E-03	0.000E+00	0.000E+00

Maximum TDOSE(t): 8.409E+00 mrem/yr at t = 0.000E+00 years

**Radium Benchmark Dose**

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.												
Ra-226	8.361E+000	0.9943	7.547E-003	0.0009	0.000E+000	0.0000	0.000E+000	0.0000	0.000E+000	0.0000	0.000E+000	0.0000	4.025E-002	0.0048
Total	8.361E+000	0.9943	7.547E-003	0.0009	0.000E+000	0.0000	0.000E+000	0.0000	0.000E+000	0.0000	0.000E+000	0.0000	4.025E-002	0.0048

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+000	0.0000	8.409E+000	1.0000										
Total	0.000E+000	0.0000	8.409E+000	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	8.078E+00	0.9936	7.464E-03	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.445E-02	0.0055
Total	8.078E+00	0.9936	7.464E-03	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.445E-02	0.0055

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	8.130E+00	1.0000										
Total	0.000E+00	0.0000	8.130E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	7.540E+00	0.9921	7.302E-03	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.264E-02	0.0069
Total	7.540E+00	0.9921	7.302E-03	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.264E-02	0.0069

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	7.600E+00	1.0000										
Total	0.000E+00	0.0000	7.600E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	5.917E+00	0.9875	6.519E-03	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.817E-02	0.0114
Total	5.917E+00	0.9875	6.519E-03	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.817E-02	0.0114

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	5.992E+00	1.0000										
Total	0.000E+00	0.0000	5.992E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	2.931E+00	0.9793	3.877E-03	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.810E-02	0.0194
Total	2.931E+00	0.9793	3.877E-03	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.810E-02	0.0194

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	2.993E+00	1.0000										
Total	0.000E+00	0.0000	2.993E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	1.979E-01	0.9776	2.300E-04	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.297E-03	0.0212
Total	1.979E-01	0.9776	2.300E-04	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.297E-03	0.0212

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	2.025E-01	1.0000										
Total	0.000E+00	0.0000	2.025E-01	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000										
Total	0.000E+00	0.0000	0.000E+00	0.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.										
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000										
Total	0.000E+00	0.0000	0.000E+00	0.0000										

\*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways  
 Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr) / (pCi/g)							
			0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-226+D	Ra-226+D	1.000E+00	1.681E+00	1.624E+00	1.516E+00	1.189E+00	5.886E-01	3.964E-02	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D	1.000E+00	3.002E-04	8.624E-04	1.827E-03	3.894E-03	4.238E-03	3.780E-04	0.000E+00	0.000E+00
Ra-226+D	Po-210	1.000E+00	1.824E-04	8.321E-04	2.202E-03	5.193E-03	5.764E-03	4.716E-04	0.000E+00	0.000E+00
Ra-226+D	$\Sigma$ DSR(j)		1.682E+00	1.626E+00	1.520E+00	1.198E+00	5.986E-01	4.049E-02	0.000E+00	0.000E+00
Ra-226+D	Ra-226+D	1.339E-06	2.251E-06	2.175E-06	2.030E-06	1.592E-06	7.881E-07	5.308E-08	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D1	1.339E-06	4.834E-10	1.390E-09	2.950E-09	6.327E-09	7.033E-09	7.125E-10	0.000E+00	0.000E+00
Ra-226+D	$\Sigma$ DSR(j)		2.252E-06	2.176E-06	2.033E-06	1.599E-06	7.952E-07	5.380E-08	0.000E+00	0.000E+00

The DSR includes contributions from associated (half-life  $\leq$  30 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g  
 Basic Radiation Dose Limit = 2.500E+01 mrem/yr

#### Nuclide

(i)	t = 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-226	1.487E+01	1.538E+01	1.645E+01	2.086E+01	4.176E+01	6.174E+02	*9.885E+11	*9.885E+11

\*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr) / (pCi/g)  
 and Single Radionuclide Soil Guidelines G(i,t) in pCi/g  
 at tmin = time of minimum single radionuclide soil guideline  
 and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin) (pCi/g)	G(i,tmin) (pCi/g)	DSR(i,tmax) (pCi/g)	G(i,tmax) (pCi/g)
Ra-226	5.000E+00	0.000E+00	1.682E+00	1.487E+01	1.682E+00	1.487E+01

RESRAD-ONSITE, Version 7.2      T<sub>1/2</sub> Limit = 30 days      08/07/2020 16:00 Page 19  
Summary : RESRAD - Fansteel Site - Outdoor Worker - Radium Benchmark Dose  
File : C:\USERS\DELHOMMK\Desktop\WESTON PROJECTS\FANSTEEL\RADIUM BENCHMARK DOSE\AUG 7\FANSTEEL RESRAD RADIUM BENCHMARK DOSE.RAD

Individual Nuclide Dose Summed Over All Pathways

Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	DOSE(j,t), mrem/yr							
(j)	(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-226	Ra-226	1.000E+00	8.406E+00	8.121E+00	7.579E+00	5.946E+00	2.943E+00	1.982E-01	0.000E+00	0.000E+00
Ra-226	Ra-226	1.339E-06	1.126E-05	1.087E-05	1.015E-05	7.962E-06	3.941E-06	2.654E-07	0.000E+00	0.000E+00
Ra-226	$\Sigma$ DOSE(j)		8.406E+00	8.121E+00	7.579E+00	5.946E+00	2.943E+00	1.982E-01	0.000E+00	0.000E+00
Pb-210	Ra-226	1.000E+00	1.501E-03	4.312E-03	9.137E-03	1.947E-02	2.119E-02	1.890E-03	0.000E+00	0.000E+00
Po-210	Ra-226	1.000E+00	9.120E-04	4.161E-03	1.101E-02	2.596E-02	2.882E-02	2.358E-03	0.000E+00	0.000E+00
Pb-210	Ra-226	1.339E-06	2.417E-09	6.948E-09	1.475E-08	3.164E-08	3.516E-08	3.563E-09	0.000E+00	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration

Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	S(j,t), pCi/g							
(j)	(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-226	Ra-226	1.000E+00	5.000E+00	4.842E+00	4.541E+00	3.628E+00	1.910E+00	2.021E-01	3.304E-04	5.831E-14
Ra-226	Ra-226	1.339E-06	6.695E-06	6.484E-06	6.081E-06	4.858E-06	2.557E-06	2.707E-07	4.424E-10	7.807E-20
Ra-226	$\Sigma$ S(j):		5.000E+00	4.842E+00	4.541E+00	3.628E+00	1.910E+00	2.021E-01	3.304E-04	5.831E-14
Pb-210	Ra-226	1.000E+00	0.000E+00	1.496E-01	4.121E-01	1.020E+00	1.322E+00	2.610E-01	4.831E-04	8.541E-14
Po-210	Ra-226	1.000E+00	0.000E+00	7.760E-02	3.137E-01	8.845E-01	1.186E+00	2.366E-01	4.386E-04	7.755E-14
Pb-210	Ra-226	1.339E-06	0.000E+00	2.003E-07	5.517E-07	1.366E-06	1.770E-06	3.494E-07	6.469E-10	1.144E-19

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.41 seconds

**ATTACHMENT 6**

**RESRAD SINGLE RADIONUCLIDE GUIDELINE LEVEL  
CALCULATION RESULTS**

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RESRAD-ONSITE, Version 7.2	T <sub>1/2</sub> Limit = 30 days	08/10/2020 09:08	Page 2	
Summary : RESRAD - Fansteel Site - Outdoor Worker - SRGLs per Radium Benchmark Dose				
File : C:\USERS\DELHOMMK\Desktop\WESTON PROJECTS\FANSTEEL\RADIUM BENCHMARK DOSE\AUG 7\FANSTEEL RESRAD RADIUM BENCHMARK DOSE.RAD				
Dose Conversion Factor (and Related) Parameter Summary				
Dose Library: DOE STD-1196-2011 (Reference Person)				
Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
A-1	DCF's for external ground radiation, (mrem/yr) / (pCi/g)			
A-1	Ac-227 (Source: DCFPAK3.02)	2.615E-04	2.615E-04	DCF1( 1)
A-1	Ac-228 (Source: DCFPAK3.02)	5.044E+00	5.044E+00	DCF1( 2)
A-1	At-218 (Source: DCFPAK3.02)	5.567E-05	5.567E-05	DCF1( 3)
A-1	At-219 (Source: DCFPAK3.02)	0.000E+00	0.000E+00	DCF1( 4)
A-1	Bi-210 (Source: DCFPAK3.02)	5.473E-03	5.473E-03	DCF1( 5)
A-1	Bi-211 (Source: DCFPAK3.02)	2.410E-01	2.410E-01	DCF1( 6)
A-1	Bi-212 (Source: DCFPAK3.02)	6.258E-01	6.258E-01	DCF1( 7)
A-1	Bi-214 (Source: DCFPAK3.02)	9.135E+00	9.135E+00	DCF1( 8)
A-1	Bi-215 (Source: DCFPAK3.02)	1.369E+00	1.369E+00	DCF1( 9)
A-1	Fr-223 (Source: DCFPAK3.02)	1.758E-01	1.758E-01	DCF1( 10)
A-1	Hg-206 (Source: DCFPAK3.02)	6.127E-01	6.127E-01	DCF1( 11)
A-1	Pa-231 (Source: DCFPAK3.02)	1.608E-01	1.608E-01	DCF1( 12)
A-1	Pa-234 (Source: DCFPAK3.02)	8.275E+00	8.275E+00	DCF1( 13)
A-1	Pa-234m (Source: DCFPAK3.02)	1.257E-01	1.257E-01	DCF1( 14)
A-1	Pb-210 (Source: DCFPAK3.02)	2.092E-03	2.092E-03	DCF1( 15)
A-1	Pb-211 (Source: DCFPAK3.02)	3.680E-01	3.680E-01	DCF1( 16)
A-1	Pb-212 (Source: DCFPAK3.02)	6.314E-01	6.314E-01	DCF1( 17)
A-1	Pb-214 (Source: DCFPAK3.02)	1.257E+00	1.257E+00	DCF1( 18)
A-1	Po-210 (Source: DCFPAK3.02)	5.641E-05	5.641E-05	DCF1( 19)
A-1	Po-211 (Source: DCFPAK3.02)	4.707E-02	4.707E-02	DCF1( 20)
A-1	Po-212 (Source: DCFPAK3.02)	0.000E+00	0.000E+00	DCF1( 21)
A-1	Po-214 (Source: DCFPAK3.02)	4.801E-04	4.801E-04	DCF1( 22)
A-1	Po-215 (Source: DCFPAK3.02)	9.452E-04	9.452E-04	DCF1( 23)
A-1	Po-216 (Source: DCFPAK3.02)	8.873E-05	8.873E-05	DCF1( 24)
A-1	Po-218 (Source: DCFPAK3.02)	9.228E-09	9.228E-09	DCF1( 25)
A-1	Ra-223 (Source: DCFPAK3.02)	5.791E-01	5.791E-01	DCF1( 26)
A-1	Ra-224 (Source: DCFPAK3.02)	4.950E-02	4.950E-02	DCF1( 27)
A-1	Ra-226 (Source: DCFPAK3.02)	3.176E-02	3.176E-02	DCF1( 28)
A-1	Ra-228 (Source: DCFPAK3.02)	6.575E-05	6.575E-05	DCF1( 29)
A-1	Rn-218 (Source: DCFPAK3.02)	4.259E-03	4.259E-03	DCF1( 30)
A-1	Rn-219 (Source: DCFPAK3.02)	2.970E-01	2.970E-01	DCF1( 31)
A-1	Rn-220 (Source: DCFPAK3.02)	3.474E-03	3.474E-03	DCF1( 32)
A-1	Rn-222 (Source: DCFPAK3.02)	2.130E-03	2.130E-03	DCF1( 33)
A-1	Th-227 (Source: DCFPAK3.02)	5.641E-01	5.641E-01	DCF1( 34)
A-1	Th-228 (Source: DCFPAK3.02)	7.248E-03	7.248E-03	DCF1( 35)
A-1	Th-230 (Source: DCFPAK3.02)	1.106E-03	1.106E-03	DCF1( 36)
A-1	Th-231 (Source: DCFPAK3.02)	3.250E-02	3.250E-02	DCF1( 37)
A-1	Th-232 (Source: DCFPAK3.02)	4.782E-04	4.782E-04	DCF1( 38)
A-1	Th-234 (Source: DCFPAK3.02)	2.316E-02	2.316E-02	DCF1( 39)
A-1	Tl-206 (Source: DCFPAK3.02)	1.278E-02	1.278E-02	DCF1( 40)
A-1	Tl-207 (Source: DCFPAK3.02)	2.391E-02	2.391E-02	DCF1( 41)
A-1	Tl-208 (Source: DCFPAK3.02)	2.167E+01	2.167E+01	DCF1( 42)
A-1	Tl-210 (Source: DCFPAK3.02)	1.677E+01	1.677E+01	DCF1( 43)
A-1	U-234 (Source: DCFPAK3.02)	3.456E-04	3.456E-04	DCF1( 44)
A-1	U-235 (Source: DCFPAK3.02)	7.005E-01	7.005E-01	DCF1( 45)
A-1	U-238 (Source: DCFPAK3.02)	1.713E-04	1.713E-04	DCF1( 46)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.714E-01	5.957E-01	DCF2( 1)

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: DOE STD-1196-2011 (Reference Person)

Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
B-1	Pa-231	8.769E-01	8.769E-01	DCF2( 2)
B-1	Pb-210+D	2.285E-02	2.231E-02	DCF2( 3)
B-1	Pb-210+D1	2.284E-02	2.231E-02	DCF2( 4)
B-1	Po-210	1.732E-02	1.732E-02	DCF2( 5)
B-1	Ra-226+D	3.823E-02	3.811E-02	DCF2( 6)
B-1	Ra-228+D	6.333E-02	6.327E-02	DCF2( 8)
B-1	Th-228+D	1.753E-01	1.610E-01	DCF2( 9)
B-1	Th-230	3.848E-01	3.848E-01	DCF2( 10)
B-1	Th-232	4.255E-01	4.255E-01	DCF2( 12)
B-1	U-234	3.737E-02	3.737E-02	DCF2( 13)
B-1	U-235+D	3.378E-02	3.378E-02	DCF2( 15)
B-1	U-238	3.212E-02	3.212E-02	DCF2( 16)
B-1	U-238+D	3.215E-02	3.212E-02	DCF2( 17)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	2.308E-03	1.450E-03	DCF3( 1)
D-1	Pa-231	2.068E-03	2.068E-03	DCF3( 2)
D-1	Pb-210+D	3.781E-03	3.774E-03	DCF3( 3)
D-1	Pb-210+D1	3.781E-03	3.774E-03	DCF3( 4)
D-1	Po-210	6.475E-03	6.475E-03	DCF3( 5)
D-1	Ra-226+D	1.677E-03	1.676E-03	DCF3( 6)
D-1	Ra-228+D	5.922E-03	5.920E-03	DCF3( 8)
D-1	Th-228+D	9.348E-04	4.292E-04	DCF3( 9)
D-1	Th-230	9.361E-04	9.361E-04	DCF3( 10)
D-1	Th-232	1.029E-03	1.029E-03	DCF3( 12)
D-1	U-234	2.150E-04	2.150E-04	DCF3( 13)
D-1	U-235+D	2.048E-04	2.031E-04	DCF3( 15)
D-1	U-238	1.939E-04	1.939E-04	DCF3( 16)
D-1	U-238+D	2.112E-04	1.939E-04	DCF3( 17)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF( 1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF( 1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF( 1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF( 2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF( 2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF( 2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF( 3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF( 3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF( 3,3)
D-34				
D-34	Pb-210+D1 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF( 4,1)
D-34	Pb-210+D1 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF( 4,2)
D-34	Pb-210+D1 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF( 4,3)
D-34				
D-34	Po-210 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF( 5,1)
D-34	Po-210 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF( 5,2)
D-34	Po-210 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.400E-04	3.400E-04	RTF( 5,3)

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: DOE STD-1196-2011 (Reference Person)

Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF( 6,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF( 6,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF( 6,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF( 8,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF( 8,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF( 8,3)
D-34				
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF( 9,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF( 9,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF( 9,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF( 10,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF( 10,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF( 10,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF( 12,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF( 12,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF( 12,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF( 13,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF( 13,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF( 13,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF( 15,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF( 15,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF( 15,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF( 16,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF( 16,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF( 16,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF( 17,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF( 17,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF( 17,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC( 1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC( 1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC( 2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC( 2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC( 3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC( 3,2)
D-5				
D-5	Pb-210+D1 , fish	3.000E+02	3.000E+02	BIOFAC( 4,1)
D-5	Pb-210+D1 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC( 4,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: DOE STD-1196-2011 (Reference Person)

Menu	Parameter	Current	Base	Parameter
		Value#	Case*	Name
D-5	Po-210 , fish	1.000E+02	1.000E+02	BIOFAC( 5,1)
D-5	Po-210 , crustacea and mollusks	2.000E+04	2.000E+04	BIOFAC( 5,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC( 6,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC( 6,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC( 8,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC( 8,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC( 9,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC( 9,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC( 10,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC( 10,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC( 12,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC( 12,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC( 13,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC( 13,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC( 15,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC( 15,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC( 16,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC( 16,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC( 17,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC( 17,2)
D-5				

#For DCF1(xxx) only, factors are for infinite depth & area. See EFTG table in Ground Pathway of Detailed Report.

\*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	8.410E+00	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T( 2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T( 3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T( 4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T( 5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T( 6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T( 7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T( 8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T( 9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	3.100E-02	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	3.100E-02	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	1.000E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Po-210	1.000E+00	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.000E+00	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): Ra-228	2.040E-01	0.000E+00	---	S1(8)
R012	Initial principal radionuclide (pCi/g): Th-228	2.100E-01	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g): Th-230	8.170E-01	0.000E+00	---	S1(10)
R012	Initial principal radionuclide (pCi/g): Th-232	2.110E-01	0.000E+00	---	S1(12)
R012	Initial principal radionuclide (pCi/g): U-234	5.370E-01	0.000E+00	---	S1(13)
R012	Initial principal radionuclide (pCi/g): U-235	3.100E-02	0.000E+00	---	S1(15)
R012	Initial principal radionuclide (pCi/g): U-238	5.530E-01	0.000E+00	---	S1(16)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0.000E+00	---	W1( 1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1( 2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1( 3)
R012	Concentration in groundwater (pCi/L): Po-210	not used	0.000E+00	---	W1( 5)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1( 6)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1( 8)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1( 9)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(10)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(12)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(13)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(15)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(16)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ

Site-Specific Parameter Summary (continued)

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
				---	
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
				---	
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
				---	
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.099E-01	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
				---	
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC( 2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU( 2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS( 2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH( 2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 2)
				---	
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC( 3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU( 3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS( 3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.217E-02	ALEACH( 3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 3)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R016	Distribution coefficients for Po-210				
R016	Contaminated zone (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCC( 5)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+01	---	DCNUCU( 5,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+01	---	DCNUCS( 5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.176E-01	ALEACH( 5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 5)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC( 6)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU( 6,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS( 6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.165E-02	ALEACH( 6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 6)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC( 8)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU( 8,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS( 8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.165E-02	ALEACH( 8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 8)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC( 9)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU( 9,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS( 9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.704E-05	ALEACH( 9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 9)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(10,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.704E-05	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(12)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(12,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(12)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.704E-05	ALEACH(12)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(12)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(13)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(13,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(13)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(13)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(13)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User		Used by RESRAD	Parameter
		Input	Default	(If different from user input)	Name
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(15)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(15,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(15)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(15)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(15)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(16)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(16,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(16)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(16)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(16)
R017	Inhalation rate (m**3/yr)	1.350E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.055E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	2.250E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Ac-227	3.100E-02
Thickness:	0.15 meters	Pa-231	3.100E-02
Cover Depth:	0.00 meters	Pb-210	1.000E+00
		Po-210	1.000E+00
		Ra-226	1.000E+00
		Ra-228	2.040E-01
		Th-228	2.100E-01
		Th-230	8.170E-01
		Th-232	2.110E-01
		U-234	5.370E-01
		U-235	3.100E-02
		U-238	5.530E-01

Total Dose TDOSE(t), mrem/yr

Basic Radiation Dose Limit = 8.410E+00 mrem/yr

Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	2.260E+00	2.189E+00	2.056E+00	1.666E+00	9.922E-01	2.801E-01	0.000E+00	0.000E+00
M(t):	2.688E-01	2.603E-01	2.444E-01	1.981E-01	1.180E-01	3.331E-02	0.000E+00	0.000E+00

Maximum TDOSE(t) : 2.260E+00 mrem/yr at t = 0.000E+00 years

Under an assumption that the ratios of the radioisotopes in the U-238, U-235, and Th-232 decay-chains to Ra-226 in the Soils Stockpile ESI sample are representative, a 'cumulative' action level for Ra-226 was calculated to equal:

Radium Benchmark Dose of 8.41 mrem/yr ÷ 2.26 mrem/yr per 1 pCi/g of Ra-226 = 3.72 pCi/g of Ra-226.  
This value can be used without the Unity Rule.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	1.092E-02	0.0048	7.692E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.074E-04	0.0001
Pa-231	1.070E-03	0.0005	1.066E-03	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.940E-04	0.0001
Pb-210	1.444E-03	0.0006	1.227E-03	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.197E-02	0.0141
Po-210	4.048E-06	0.0000	2.923E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.271E-02	0.0056
Ra-226	1.672E+00	0.7398	1.509E-03	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.050E-03	0.0036
Ra-228	2.035E-01	0.0900	6.919E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.299E-03	0.0023
Th-228	2.494E-01	0.1103	1.224E-03	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.589E-04	0.0003
Th-230	4.718E-04	0.0002	1.246E-02	0.0055	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.526E-03	0.0016
Th-232	1.212E-02	0.0054	3.598E-03	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.336E-03	0.0006
U-234	3.692E-05	0.0000	7.782E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.204E-04	0.0002
U-235	4.202E-03	0.0019	4.062E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.863E-05	0.0000
U-238	1.535E-02	0.0068	6.893E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.265E-04	0.0002
Total	2.171E+00	0.9603	2.435E-02	0.0108	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.532E-02	0.0289

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	1.200E-02	0.0053										
Pa-231	0.000E+00	0.0000	2.431E-03	0.0011										
Pb-210	0.000E+00	0.0000	3.464E-02	0.0153										
Po-210	0.000E+00	0.0000	1.300E-02	0.0058										
Ra-226	0.000E+00	0.0000	1.682E+00	0.7440										
Ra-228	0.000E+00	0.0000	2.095E-01	0.0927										
Th-228	0.000E+00	0.0000	2.514E-01	0.1112										
Th-230	0.000E+00	0.0000	1.646E-02	0.0073										
Th-232	0.000E+00	0.0000	1.705E-02	0.0075										
U-234	0.000E+00	0.0000	1.335E-03	0.0006										
U-235	0.000E+00	0.0000	4.271E-03	0.0019										
U-238	0.000E+00	0.0000	1.656E-02	0.0073										
Total	0.000E+00	0.0000	2.260E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	9.467E-03	0.0043	6.631E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.650E-04	0.0001
Pa-231	1.339E-03	0.0006	1.036E-03	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.882E-04	0.0001
Pb-210	1.372E-03	0.0006	1.374E-03	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.959E-02	0.0181
Po-210	5.217E-07	0.0000	3.750E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-03	0.0007
Ra-226	1.616E+00	0.7379	1.493E-03	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.889E-03	0.0041
Ra-228	2.422E-01	0.1106	9.220E-04	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.726E-03	0.0022
Th-228	1.731E-01	0.0791	8.462E-04	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.246E-04	0.0002
Th-230	1.052E-03	0.0005	1.238E-02	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.505E-03	0.0016
Th-232	4.019E-02	0.0184	3.676E-03	0.0017	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.949E-03	0.0009
U-234	3.532E-05	0.0000	7.396E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.946E-04	0.0002
U-235	4.016E-03	0.0018	3.862E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.721E-05	0.0000
U-238	1.466E-02	0.0067	6.551E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.003E-04	0.0002
Total	2.103E+00	0.9606	2.386E-02	0.0109	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.239E-02	0.0285

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	1.040E-02	0.0047										
Pa-231	0.000E+00	0.0000	2.663E-03	0.0012										
Pb-210	0.000E+00	0.0000	4.233E-02	0.0193										
Po-210	0.000E+00	0.0000	1.668E-03	0.0008										
Ra-226	0.000E+00	0.0000	1.626E+00	0.7427										
Ra-228	0.000E+00	0.0000	2.479E-01	0.1132										
Th-228	0.000E+00	0.0000	1.745E-01	0.0797										
Th-230	0.000E+00	0.0000	1.694E-02	0.0077										
Th-232	0.000E+00	0.0000	4.581E-02	0.0209										
U-234	0.000E+00	0.0000	1.269E-03	0.0006										
U-235	0.000E+00	0.0000	4.082E-03	0.0019										
U-238	0.000E+00	0.0000	1.582E-02	0.0072										
Total	0.000E+00	0.0000	2.189E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	7.109E-03	0.0035	4.926E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.969E-04	0.0001
Pa-231	1.722E-03	0.0008	9.697E-04	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.741E-04	0.0001
Pb-210	1.232E-03	0.0006	1.248E-03	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.640E-02	0.0177
Po-210	8.657E-09	0.0000	6.166E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.681E-05	0.0000
Ra-226	1.508E+00	0.7335	1.460E-03	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.053E-02	0.0051
Ra-228	2.508E-01	0.1220	1.025E-03	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.658E-03	0.0018
Th-228	8.336E-02	0.0406	4.042E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.506E-04	0.0001
Th-230	2.150E-03	0.0010	1.221E-02	0.0059	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.464E-03	0.0017
Th-232	1.027E-01	0.0499	3.875E-03	0.0019	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.958E-03	0.0014
U-234	3.233E-05	0.0000	6.680E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.466E-04	0.0002
U-235	3.669E-03	0.0018	3.492E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.458E-05	0.0000
U-238	1.337E-02	0.0065	5.915E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.518E-04	0.0002
Total	1.974E+00	0.9603	2.298E-02	0.0112	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.868E-02	0.0285

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	7.799E-03	0.0038										
Pa-231	0.000E+00	0.0000	2.966E-03	0.0014										
Pb-210	0.000E+00	0.0000	3.888E-02	0.0189										
Po-210	0.000E+00	0.0000	2.743E-05	0.0000										
Ra-226	0.000E+00	0.0000	1.520E+00	0.7394										
Ra-228	0.000E+00	0.0000	2.555E-01	0.1243										
Th-228	0.000E+00	0.0000	8.402E-02	0.0409										
Th-230	0.000E+00	0.0000	1.783E-02	0.0087										
Th-232	0.000E+00	0.0000	1.095E-01	0.0533										
U-234	0.000E+00	0.0000	1.147E-03	0.0006										
U-235	0.000E+00	0.0000	3.729E-03	0.0018										
U-238	0.000E+00	0.0000	1.442E-02	0.0070										
Total	0.000E+00	0.0000	2.056E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.607E-03	0.0016	1.739E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.950E-05	0.0000
Pa-231	2.083E-03	0.0013	7.328E-04	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.136E-04	0.0001
Pb-210	8.449E-04	0.0005	8.181E-04	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.387E-02	0.0143
Po-210	5.090E-15	0.0000	3.510E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.526E-11	0.0000
Ra-226	1.183E+00	0.7104	1.304E-03	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.363E-02	0.0082
Ra-228	1.212E-01	0.0728	5.074E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.307E-03	0.0008
Th-228	6.458E-03	0.0039	3.040E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.885E-05	0.0000
Th-230	5.400E-03	0.0032	1.163E-02	0.0070	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.328E-03	0.0020
Th-232	2.631E-01	0.1580	4.354E-03	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.774E-03	0.0029
U-234	2.380E-05	0.0000	4.670E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.121E-04	0.0002
U-235	2.672E-03	0.0016	2.449E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.720E-05	0.0000
U-238	9.693E-03	0.0058	4.132E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.156E-04	0.0002
Total	1.597E+00	0.9590	2.045E-02	0.0123	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.786E-02	0.0287

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	2.851E-03	0.0017										
Pa-231	0.000E+00	0.0000	3.030E-03	0.0018										
Pb-210	0.000E+00	0.0000	2.553E-02	0.0153										
Po-210	0.000E+00	0.0000	1.561E-11	0.0000										
Ra-226	0.000E+00	0.0000	1.198E+00	0.7194										
Ra-228	0.000E+00	0.0000	1.230E-01	0.0738										
Th-228	0.000E+00	0.0000	6.507E-03	0.0039										
Th-230	0.000E+00	0.0000	2.036E-02	0.0122										
Th-232	0.000E+00	0.0000	2.723E-01	0.1634										
U-234	0.000E+00	0.0000	8.029E-04	0.0005										
U-235	0.000E+00	0.0000	2.713E-03	0.0016										
U-238	0.000E+00	0.0000	1.042E-02	0.0063										
Total	0.000E+00	0.0000	1.666E+00	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	1.472E-04	0.0001	8.743E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.494E-06	0.0000
Pa-231	1.116E-03	0.0011	2.762E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.237E-05	0.0001
Pb-210	2.867E-04	0.0003	2.409E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.028E-03	0.0071
Po-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.162E-29	0.0000
Ra-226	5.862E-01	0.5908	7.755E-04	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.162E-02	0.0117
Ra-228	5.895E-03	0.0059	2.276E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.460E-05	0.0001
Th-228	4.284E-06	0.0000	1.844E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.143E-08	0.0000
Th-230	1.090E-02	0.0110	9.958E-03	0.0100	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.935E-03	0.0030
Th-232	3.401E-01	0.3428	4.085E-03	0.0041	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.971E-03	0.0050
U-234	1.042E-05	0.0000	1.659E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.106E-04	0.0001
U-235	1.072E-03	0.0011	8.774E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.115E-06	0.0000
U-238	3.833E-03	0.0039	1.461E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.116E-04	0.0001
Total	9.496E-01	0.9571	1.569E-02	0.0158	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.692E-02	0.0271

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	1.594E-04	0.0002										
Pa-231	0.000E+00	0.0000	1.475E-03	0.0015										
Pb-210	0.000E+00	0.0000	7.555E-03	0.0076										
Po-210	0.000E+00	0.0000	2.162E-29	0.0000										
Ra-226	0.000E+00	0.0000	5.986E-01	0.6033										
Ra-228	0.000E+00	0.0000	5.973E-03	0.0060										
Th-228	0.000E+00	0.0000	4.314E-06	0.0000										
Th-230	0.000E+00	0.0000	2.379E-02	0.0240										
Th-232	0.000E+00	0.0000	3.492E-01	0.3519										
U-234	0.000E+00	0.0000	2.869E-04	0.0003										
U-235	0.000E+00	0.0000	1.087E-03	0.0011										
U-238	0.000E+00	0.0000	4.090E-03	0.0041										
Total	0.000E+00	0.0000	9.922E-01	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	4.970E-09	0.0000	1.774E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.091E-11	0.0000
Pa-231	3.615E-05	0.0001	5.210E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.559E-06	0.0000
Pb-210	6.000E-06	0.0000	2.375E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.930E-05	0.0002
Po-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.959E-02	0.1413	4.599E-05	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.593E-04	0.0031
Ra-228	8.882E-08	0.0000	2.229E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.343E-10	0.0000
Th-228	2.575E-17	0.0000	7.225E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.479E-20	0.0000
Th-230	1.063E-02	0.0380	4.115E-03	0.0147	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.274E-03	0.0045
Th-232	2.195E-01	0.7837	1.696E-03	0.0061	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.072E-03	0.0074
U-234	1.710E-06	0.0000	3.639E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.232E-06	0.0000
U-235	3.513E-05	0.0001	1.718E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.167E-07	0.0000
U-238	1.224E-04	0.0004	2.733E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.087E-06	0.0000
Total	2.700E-01	0.9638	5.871E-03	0.0210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.281E-03	0.0153

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	5.218E-09	0.0000										
Pa-231	0.000E+00	0.0000	4.292E-05	0.0002										
Pb-210	0.000E+00	0.0000	7.768E-05	0.0003										
Po-210	0.000E+00	0.0000	0.000E+00	0.0000										
Ra-226	0.000E+00	0.0000	4.049E-02	0.1446										
Ra-228	0.000E+00	0.0000	8.958E-08	0.0000										
Th-228	0.000E+00	0.0000	2.586E-17	0.0000										
Th-230	0.000E+00	0.0000	1.602E-02	0.0572										
Th-232	0.000E+00	0.0000	2.233E-01	0.7972										
U-234	0.000E+00	0.0000	7.581E-06	0.0000										
U-235	0.000E+00	0.0000	3.542E-05	0.0001										
U-238	0.000E+00	0.0000	1.272E-04	0.0005										
Total	0.000E+00	0.0000	2.801E-01	1.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Po-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000										
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000										
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000										
Po-210	0.000E+00	0.0000	0.000E+00	0.0000										
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000										
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000										
Th-228	0.000E+00	0.0000	0.000E+00	0.0000										
Th-230	0.000E+00	0.0000	0.000E+00	0.0000										
Th-232	0.000E+00	0.0000	0.000E+00	0.0000										
U-234	0.000E+00	0.0000	0.000E+00	0.0000										
U-235	0.000E+00	0.0000	0.000E+00	0.0000										
U-238	0.000E+00	0.0000	0.000E+00	0.0000										
Total	0.000E+00	0.0000	0.000E+00	0.0000										

\*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Po-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.										
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000										
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000										
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000										
Po-210	0.000E+00	0.0000	0.000E+00	0.0000										
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000										
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000										
Th-228	0.000E+00	0.0000	0.000E+00	0.0000										
Th-230	0.000E+00	0.0000	0.000E+00	0.0000										
Th-232	0.000E+00	0.0000	0.000E+00	0.0000										
U-234	0.000E+00	0.0000	0.000E+00	0.0000										
U-235	0.000E+00	0.0000	0.000E+00	0.0000										
U-238	0.000E+00	0.0000	0.000E+00	0.0000										
Total	0.000E+00	0.0000	0.000E+00	0.0000										

\*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways

Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr) / (pCi/g)							
			0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227+D	Ac-227+D	1.000E+00	3.871E-01	3.353E-01	2.516E-01	9.196E-02	5.142E-03	1.683E-07	0.000E+00	0.000E+00
Pa-231	Pa-231	1.000E+00	7.220E-02	6.876E-02	6.235E-02	4.424E-02	1.642E-02	3.957E-04	0.000E+00	0.000E+00
Pa-231	Ac-227+D	1.000E+00	6.213E-03	1.715E-02	3.332E-02	5.349E-02	3.114E-02	9.887E-04	0.000E+00	0.000E+00
Pa-231	ΣDSR(j)		7.841E-02	8.590E-02	9.567E-02	9.773E-02	4.756E-02	1.384E-03	0.000E+00	0.000E+00
Pb-210+D	Pb-210+D	1.000E+00	1.929E-02	1.817E-02	1.613E-02	1.060E-02	3.160E-03	3.433E-05	0.000E+00	0.000E+00
Pb-210+D	Po-210	1.000E+00	1.535E-02	2.416E-02	2.276E-02	1.493E-02	4.395E-03	4.335E-05	0.000E+00	0.000E+00
Pb-210+D	ΣDSR(j)		3.464E-02	4.233E-02	3.888E-02	2.553E-02	7.555E-03	7.768E-05	0.000E+00	0.000E+00
Pb-210+D1	Pb-210+D1	1.339E-06	3.105E-08	2.928E-08	2.603E-08	1.723E-08	5.244E-09	6.471E-11	0.000E+00	0.000E+00
Po-210	Po-210	1.000E+00	1.300E-02	1.668E-03	2.743E-05	1.561E-11	2.213E-29	0.000E+00	0.000E+00	0.000E+00
Ra-226+D	Ra-226+D	1.000E+00	1.681E+00	1.624E+00	1.516E+00	1.189E+00	5.886E-01	3.964E-02	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D	1.000E+00	3.002E-04	8.624E-04	1.827E-03	3.894E-03	4.238E-03	3.780E-04	0.000E+00	0.000E+00
Ra-226+D	Po-210	1.000E+00	1.823E-04	8.321E-04	2.202E-03	5.193E-03	5.764E-03	4.716E-04	0.000E+00	0.000E+00
Ra-226+D	ΣDSR(j)		1.682E+00	1.626E+00	1.520E+00	1.198E+00	5.986E-01	4.049E-02	0.000E+00	0.000E+00
Ra-226+D	Ra-226+D	1.339E-06	2.251E-06	2.175E-06	2.030E-06	1.592E-06	7.881E-07	5.308E-08	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D1	1.339E-06	4.834E-10	1.390E-09	2.950E-09	6.327E-09	7.033E-09	7.125E-10	0.000E+00	0.000E+00
Ra-226+D	ΣDSR(j)		2.252E-06	2.176E-06	2.033E-06	1.599E-06	7.952E-07	5.380E-08	0.000E+00	0.000E+00
Ra-228+D	Ra-228+D	1.000E+00	8.086E-01	6.928E-01	5.085E-01	1.721E-01	7.712E-03	1.157E-07	0.000E+00	0.000E+00
Ra-228+D	Th-228+D	1.000E+00	2.184E-01	5.224E-01	7.440E-01	4.309E-01	2.157E-02	3.234E-07	0.000E+00	0.000E+00
Ra-228+D	ΣDSR(j)		1.027E+00	1.215E+00	1.252E+00	6.030E-01	2.928E-02	4.391E-07	0.000E+00	0.000E+00
Th-228+D	Th-228+D	1.000E+00	1.197E+00	8.307E-01	4.001E-01	3.099E-02	2.054E-05	1.232E-16	0.000E+00	0.000E+00
Th-230	Th-230	1.000E+00	1.978E-02	1.965E-02	1.938E-02	1.846E-02	1.583E-02	6.618E-03	0.000E+00	0.000E+00
Th-230	Ra-226+D	1.000E+00	3.660E-04	1.080E-03	2.431E-03	6.429E-03	1.319E-02	1.288E-02	0.000E+00	0.000E+00
Th-230	Pb-210+D	1.000E+00	4.364E-08	2.966E-07	1.466E-06	1.034E-05	4.494E-05	5.250E-05	0.000E+00	0.000E+00
Th-230	Po-210	1.000E+00	2.154E-08	2.323E-07	1.551E-06	1.307E-05	5.967E-05	6.447E-05	0.000E+00	0.000E+00
Th-230	ΣDSR(j)		2.015E-02	2.073E-02	2.182E-02	2.491E-02	2.912E-02	1.961E-02	0.000E+00	0.000E+00
Th-230	Th-230	1.339E-06	2.649E-08	2.631E-08	2.596E-08	2.472E-08	2.119E-08	8.861E-09	0.000E+00	0.000E+00
Th-230	Ra-226+D	1.339E-06	4.900E-10	1.446E-09	3.255E-09	8.609E-09	1.766E-08	1.724E-08	0.000E+00	0.000E+00
Th-230	Pb-210+D1	1.339E-06	7.027E-14	4.779E-13	2.366E-12	1.680E-11	7.458E-11	9.897E-11	0.000E+00	0.000E+00
Th-230	ΣDSR(j)		2.698E-08	2.776E-08	2.921E-08	3.335E-08	3.892E-08	2.620E-08	0.000E+00	0.000E+00
Th-232	Th-232	1.000E+00	2.170E-02	2.156E-02	2.127E-02	2.025E-02	1.735E-02	7.210E-03	0.000E+00	0.000E+00
Th-232	Ra-228+D	1.000E+00	4.995E-02	1.400E-01	2.826E-01	5.367E-01	6.265E-01	4.009E-01	0.000E+00	0.000E+00
Th-232	Th-228+D	1.000E+00	9.155E-03	5.553E-02	2.150E-01	7.333E-01	1.011E+00	6.502E-01	0.000E+00	0.000E+00
Th-232	ΣDSR(j)		8.081E-02	2.171E-01	5.189E-01	1.290E+00	1.655E+00	1.058E+00	0.000E+00	0.000E+00

Dose/Source Ratios Summed Over All Pathways  
 Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr) / (pCi/g)							
			0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	2.487E-03	2.364E-03	2.135E-03	1.493E-03	5.303E-04	1.027E-05	0.000E+00	0.000E+00
U-234	Th-230	1.000E+00	8.952E-08	2.618E-07	5.776E-07	1.426E-06	2.437E-06	1.360E-06	0.000E+00	0.000E+00
U-234	Ra-226+D	1.000E+00	1.112E-09	7.602E-09	3.808E-08	2.814E-07	1.391E-06	2.471E-06	0.000E+00	0.000E+00
U-234	Pb-210+D	1.000E+00	9.984E-14	1.449E-12	1.570E-11	3.189E-10	3.663E-09	9.428E-09	0.000E+00	0.000E+00
U-234	Po-210	1.000E+00	4.169E-14	9.729E-13	1.496E-11	3.869E-10	4.798E-09	1.156E-08	0.000E+00	0.000E+00
U-234	$\Sigma$ DSR(j)		2.487E-03	2.364E-03	2.136E-03	1.495E-03	5.342E-04	1.412E-05	0.000E+00	0.000E+00
U-234	U-234	1.339E-06	3.330E-09	3.165E-09	2.859E-09	2.000E-09	7.101E-10	1.375E-11	0.000E+00	0.000E+00
U-234	Th-230	1.339E-06	1.199E-13	3.506E-13	7.734E-13	1.909E-12	3.263E-12	1.821E-12	0.000E+00	0.000E+00
U-234	Ra-226+D	1.339E-06	1.489E-15	1.018E-14	5.099E-14	3.768E-13	1.863E-12	3.308E-12	0.000E+00	0.000E+00
U-234	Pb-210+D1	1.339E-06	1.608E-19	2.335E-18	2.535E-17	5.182E-16	6.079E-15	1.777E-14	0.000E+00	0.000E+00
U-234	$\Sigma$ DSR(j)		3.330E-09	3.165E-09	2.860E-09	2.002E-09	7.153E-10	1.889E-11	0.000E+00	0.000E+00
U-235+D	U-235+D	1.000E+00	1.378E-01	1.317E-01	1.203E-01	8.751E-02	3.503E-02	1.140E-03	0.000E+00	0.000E+00
U-235+D	Pa-231	1.000E+00	7.576E-07	2.176E-06	4.612E-06	9.825E-06	1.060E-05	8.423E-07	0.000E+00	0.000E+00
U-235+D	Ac-227+D	1.000E+00	4.400E-08	2.881E-07	1.311E-06	6.940E-06	1.442E-05	1.890E-06	0.000E+00	0.000E+00
U-235+D	$\Sigma$ DSR(j)		1.378E-01	1.317E-01	1.203E-01	8.753E-02	3.506E-02	1.142E-03	0.000E+00	0.000E+00
U-238	U-238	5.450E-07	1.173E-09	1.115E-09	1.007E-09	7.036E-10	2.493E-10	4.742E-12	0.000E+00	0.000E+00
U-238+D	U-238+D	1.000E+00	2.995E-02	2.860E-02	2.607E-02	1.885E-02	7.396E-03	2.300E-04	0.000E+00	0.000E+00
U-238+D	U-234	1.000E+00	3.481E-09	9.982E-09	2.107E-08	4.426E-08	4.567E-08	2.913E-09	0.000E+00	0.000E+00
U-238+D	Th-230	1.000E+00	8.358E-14	5.673E-13	2.797E-12	1.951E-11	8.204E-11	8.228E-11	0.000E+00	0.000E+00
U-238+D	Ra-226+D	1.000E+00	7.810E-16	1.139E-14	1.249E-13	2.647E-12	3.428E-11	1.343E-10	0.000E+00	0.000E+00
U-238+D	Pb-210+D	1.000E+00	5.620E-20	1.682E-18	3.920E-17	2.307E-15	7.258E-14	4.698E-13	0.000E+00	0.000E+00
U-238+D	Po-210	1.000E+00	2.036E-20	9.955E-19	3.403E-17	2.688E-15	9.373E-14	5.743E-13	0.000E+00	0.000E+00
U-238+D	$\Sigma$ DSR(j)		2.995E-02	2.860E-02	2.607E-02	1.885E-02	7.396E-03	2.300E-04	0.000E+00	0.000E+00
U-238+D	U-238+D	1.339E-06	4.011E-08	3.830E-08	3.491E-08	2.523E-08	9.904E-09	3.080E-10	0.000E+00	0.000E+00
U-238+D	U-234	1.339E-06	4.661E-15	1.337E-14	2.822E-14	5.926E-14	6.115E-14	3.901E-15	0.000E+00	0.000E+00
U-238+D	Th-230	1.339E-06	1.119E-19	7.596E-19	3.745E-18	2.613E-17	1.099E-16	1.102E-16	0.000E+00	0.000E+00
U-238+D	Ra-226+D	1.339E-06	1.046E-21	1.526E-20	1.673E-19	3.544E-18	4.590E-17	1.798E-16	0.000E+00	0.000E+00
U-238+D	Pb-210+D1	1.339E-06	9.050E-26	2.710E-24	6.327E-23	3.749E-21	1.204E-19	8.856E-19	0.000E+00	0.000E+00
U-238+D	$\Sigma$ DSR(j)		4.011E-08	3.830E-08	3.491E-08	2.523E-08	9.904E-09	3.080E-10	0.000E+00	0.000E+00

The DSR includes contributions from associated (half-life ≤ 30 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g

Basic Radiation Dose Limit = 8.410E+00 mrem/yr

Nuclide (i)	t = 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	2.172E+01	2.508E+01	3.343E+01	9.146E+01	1.636E+03	4.996E+07	*7.232E+13	*7.232E+13
Pa-231	1.073E+02	9.790E+01	8.790E+01	8.606E+01	1.768E+02	6.075E+03	*4.723E+10	*4.723E+10
Pb-210	2.428E+02	1.987E+02	2.163E+02	3.294E+02	1.113E+03	1.083E+05	*7.632E+13	*7.632E+13
Po-210	6.467E+02	5.041E+03	3.066E+05	5.386E+11	*4.472E+15	*4.472E+15	*4.472E+15	*4.472E+15
Ra-226	5.001E+00	5.172E+00	5.533E+00	7.018E+00	1.405E+01	2.077E+02	*9.885E+11	*9.885E+11
Ra-228	8.189E+00	6.921E+00	6.715E+00	1.395E+01	2.872E+02	1.915E+07	*2.726E+14	*2.726E+14
Th-228	7.026E+00	1.012E+01	2.102E+01	2.714E+02	4.094E+05	*8.201E+14	*8.201E+14	*8.201E+14
Th-230	4.175E+02	4.057E+02	3.855E+02	3.376E+02	2.888E+02	4.289E+02	*2.062E+10	*2.062E+10
Th-232	1.041E+02	3.873E+01	1.621E+01	6.518E+00	5.082E+00	7.947E+00	*1.097E+05	*1.097E+05
U-234	3.382E+03	3.558E+03	3.938E+03	5.625E+03	1.574E+04	5.957E+05	*6.222E+09	*6.222E+09
U-235	6.104E+01	6.386E+01	6.992E+01	9.608E+01	2.399E+02	7.361E+03	*2.160E+06	*2.160E+06
U-238	2.808E+02	2.941E+02	3.226E+02	4.463E+02	1.137E+03	3.656E+04	*3.361E+05	*3.361E+05

\*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr) / (pCi/g)

and Single Radionuclide Soil Guidelines G(i,t) in pCi/g

at tmin = time of minimum single radionuclide soil guideline

and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin) (pCi/g)	G(i,tmin) (pCi/g)	DSR(i,tmax) (pCi/g)	G(i,tmax) (pCi/g)
Ac-227	3.100E-02	0.000E+00	3.871E-01	2.172E+01	3.871E-01	2.172E+01
Pa-231	3.100E-02	6.54 ± 0.01	1.011E-01	8.321E+01	7.841E-02	1.073E+02
Pb-210	1.000E+00	1.089 ± 0.002	4.236E-02	1.985E+02	3.464E-02	2.428E+02
Po-210	1.000E+00	0.000E+00	1.300E-02	6.467E+02	1.300E-02	6.467E+02
Ra-226	1.000E+00	0.000E+00	1.682E+00	5.001E+00	1.682E+00	5.001E+00
Ra-228	2.040E-01	2.159 ± 0.004	1.275E+00	6.598E+00	1.027E+00	8.189E+00
Th-228	2.100E-01	0.000E+00	1.197E+00	7.026E+00	1.197E+00	7.026E+00
Th-230	8.170E-01	38.56 ± 0.08	2.945E-02	2.856E+02	2.015E-02	4.175E+02
Th-232	2.110E-01	26.67 ± 0.05	1.660E+00	5.067E+00	8.081E-02	1.041E+02
U-234	5.370E-01	0.000E+00	2.487E-03	3.382E+03	2.487E-03	3.382E+03
U-235	3.100E-02	0.000E+00	1.378E-01	6.104E+01	1.378E-01	6.104E+01
U-238	5.530E-01	0.000E+00	2.995E-02	2.808E+02	2.995E-02	2.808E+02

RESRAD-ONSITE, Version 7.2      T½ Limit = 30 days      08/10/2020 09:08 Page 25  
 Summary : RESRAD - Fansteel Site - Outdoor Worker - SRGLs per Radium Benchmark Dose  
 File : C:\USERS\DELHOMMK\Desktop\WESTON PROJECTS\FANSTEEL\RADIUM BENCHMARK DOSE\AUG 7\FANSTEEL RESRAD RADIUM BENCHMARK DOSE.RAD

Individual Nuclide Dose Summed Over All Pathways  
 Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	DOSE(j,t), mrem/yr							
(j)	(i)	t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03								
Ac-227	Ac-227	1.000E+00	1.200E-02	1.040E-02	7.799E-03	2.851E-03	1.594E-04	5.218E-09	0.000E+00	0.000E+00
Ac-227	Pa-231	1.000E+00	1.926E-04	5.315E-04	1.033E-03	1.658E-03	9.654E-04	3.065E-05	0.000E+00	0.000E+00
Ac-227	U-235	1.000E+00	1.364E-09	8.931E-09	4.063E-08	2.151E-07	4.471E-07	5.858E-08	0.000E+00	0.000E+00
Ac-227	ΣDOSE(j)		1.219E-02	1.093E-02	8.832E-03	4.509E-03	1.125E-03	3.071E-05	0.000E+00	0.000E+00
Pa-231	Pa-231	1.000E+00	2.238E-03	2.131E-03	1.933E-03	1.371E-03	5.091E-04	1.227E-05	0.000E+00	0.000E+00
Pa-231	U-235	1.000E+00	2.349E-08	6.747E-08	1.430E-07	3.046E-07	3.286E-07	2.611E-08	0.000E+00	0.000E+00
Pa-231	ΣDOSE(j)		2.238E-03	2.132E-03	1.933E-03	1.372E-03	5.095E-04	1.229E-05	0.000E+00	0.000E+00
Pb-210	Pb-210	1.000E+00	1.929E-02	1.817E-02	1.613E-02	1.060E-02	3.160E-03	3.433E-05	0.000E+00	0.000E+00
Pb-210	Pb-210	1.339E-06	3.105E-08	2.928E-08	2.603E-08	1.723E-08	5.244E-09	6.471E-11	0.000E+00	0.000E+00
Pb-210	Ra-226	1.000E+00	3.002E-04	8.624E-04	1.827E-03	3.894E-03	4.238E-03	3.780E-04	0.000E+00	0.000E+00
Pb-210	Th-230	1.000E+00	3.566E-08	2.423E-07	1.198E-06	8.446E-06	3.672E-05	4.289E-05	0.000E+00	0.000E+00
Pb-210	U-234	1.000E+00	5.361E-14	7.781E-13	8.432E-12	1.713E-10	1.967E-09	5.063E-09	0.000E+00	0.000E+00
Pb-210	U-238	1.000E+00	3.108E-20	9.300E-19	2.168E-17	1.276E-15	4.014E-14	2.598E-13	0.000E+00	0.000E+00
Pb-210	ΣDOSE(j)		1.959E-02	1.903E-02	1.795E-02	1.451E-02	7.435E-03	4.552E-04	0.000E+00	0.000E+00
Po-210	Pb-210	1.000E+00	1.535E-02	2.416E-02	2.276E-02	1.493E-02	4.395E-03	4.335E-05	0.000E+00	0.000E+00
Po-210	Po-210	1.000E+00	1.300E-02	1.668E-03	2.743E-05	1.561E-11	2.162E-29	0.000E+00	0.000E+00	0.000E+00
Po-210	Ra-226	1.000E+00	1.823E-04	8.321E-04	2.202E-03	5.193E-03	5.764E-03	4.716E-04	0.000E+00	0.000E+00
Po-210	Th-230	1.000E+00	1.760E-08	1.898E-07	1.267E-06	1.068E-05	4.875E-05	5.268E-05	0.000E+00	0.000E+00
Po-210	U-234	1.000E+00	2.239E-14	5.225E-13	8.033E-12	2.078E-10	2.577E-09	6.206E-09	0.000E+00	0.000E+00
Po-210	U-238	1.000E+00	1.126E-20	5.505E-19	1.882E-17	1.486E-15	5.183E-14	3.176E-13	0.000E+00	0.000E+00
Po-210	ΣDOSE(j)		2.854E-02	2.666E-02	2.499E-02	2.013E-02	1.021E-02	5.677E-04	0.000E+00	0.000E+00
Ra-226	Ra-226	1.000E+00	1.681E+00	1.624E+00	1.516E+00	1.189E+00	5.886E-01	3.964E-02	0.000E+00	0.000E+00
Ra-226	Ra-226	1.339E-06	2.251E-06	2.175E-06	2.030E-06	1.592E-06	7.881E-07	5.308E-08	0.000E+00	0.000E+00
Ra-226	Th-230	1.000E+00	2.990E-04	8.825E-04	1.986E-03	5.253E-03	1.077E-02	1.052E-02	0.000E+00	0.000E+00
Ra-226	Th-230	1.339E-06	4.004E-10	1.182E-09	2.660E-09	7.034E-09	1.442E-08	1.409E-08	0.000E+00	0.000E+00
Ra-226	U-234	1.000E+00	5.972E-10	4.082E-09	2.045E-08	1.511E-07	7.472E-07	1.327E-06	0.000E+00	0.000E+00
Ra-226	U-234	1.339E-06	7.997E-16	5.466E-15	2.738E-14	2.023E-13	1.000E-12	1.777E-12	0.000E+00	0.000E+00
Ra-226	U-238	1.000E+00	4.319E-16	6.301E-15	6.908E-14	1.464E-12	1.896E-11	7.425E-11	0.000E+00	0.000E+00
Ra-226	U-238	1.339E-06	5.783E-22	8.437E-21	9.250E-20	1.960E-18	2.538E-17	9.942E-17	0.000E+00	0.000E+00
Ra-226	ΣDOSE(j)		1.682E+00	1.625E+00	1.518E+00	1.194E+00	5.994E-01	5.016E-02	0.000E+00	0.000E+00
Pb-210	Ra-226	1.339E-06	4.834E-10	1.390E-09	2.950E-09	6.327E-09	7.033E-09	7.125E-10	0.000E+00	0.000E+00
Pb-210	Th-230	1.339E-06	5.741E-14	3.904E-13	1.933E-12	1.372E-11	6.093E-11	8.086E-11	0.000E+00	0.000E+00
Pb-210	U-234	1.339E-06	8.632E-20	1.254E-18	1.361E-17	2.783E-16	3.264E-15	9.545E-15	0.000E+00	0.000E+00
Pb-210	U-238	1.339E-06	5.004E-26	1.499E-24	3.499E-23	2.073E-21	6.660E-20	4.898E-19	0.000E+00	0.000E+00
Pb-210	ΣDOSE(j)		4.834E-10	1.390E-09	2.952E-09	6.341E-09	7.093E-09	7.934E-10	0.000E+00	0.000E+00
Ra-228	Ra-228	1.000E+00	1.650E-01	1.413E-01	1.037E-01	3.511E-02	1.573E-03	2.361E-08	0.000E+00	0.000E+00
Ra-228	Th-232	1.000E+00	1.054E-02	2.955E-02	5.964E-02	1.133E-01	1.322E-01	8.459E-02	0.000E+00	0.000E+00
Ra-228	ΣDOSE(j)		1.755E-01	1.709E-01	1.634E-01	1.484E-01	1.338E-01	8.459E-02	0.000E+00	0.000E+00
Th-228	Ra-228	1.000E+00	4.456E-02	1.066E-01	1.518E-01	8.790E-02	4.399E-03	6.597E-08	0.000E+00	0.000E+00
Th-228	Th-228	1.000E+00	2.514E-01	1.745E-01	8.402E-02	6.507E-03	4.314E-06	2.586E-17	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	1.932E-03	1.172E-02	4.537E-02	1.547E-01	2.133E-01	1.372E-01	0.000E+00	0.000E+00
Th-228	ΣDOSE(j)		2.979E-01	2.927E-01	2.812E-01	2.491E-01	2.178E-01	1.372E-01	0.000E+00	0.000E+00

Individual Nuclide Dose Summed Over All Pathways

Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	DOSE(j,t), mrem/yr							
(j)	(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Th-230	Th-230	1.000E+00	1.616E-02	1.605E-02	1.584E-02	1.508E-02	1.293E-02	5.407E-03	0.000E+00	0.000E+00
Th-230	Th-230	1.339E-06	2.164E-08	2.149E-08	2.121E-08	2.020E-08	1.732E-08	7.240E-09	0.000E+00	0.000E+00
Th-230	U-234	1.000E+00	4.807E-08	1.406E-07	3.102E-07	7.656E-07	1.309E-06	7.304E-07	0.000E+00	0.000E+00
Th-230	U-234	1.339E-06	6.437E-14	1.883E-13	4.153E-13	1.025E-12	1.752E-12	9.781E-13	0.000E+00	0.000E+00
Th-230	U-238	1.000E+00	4.622E-14	3.137E-13	1.546E-12	1.079E-11	4.537E-11	4.550E-11	0.000E+00	0.000E+00
Th-230	U-238	1.339E-06	6.189E-20	4.201E-19	2.071E-18	1.445E-17	6.075E-17	6.092E-17	0.000E+00	0.000E+00
Th-230	ΣDOSE(j)		1.616E-02	1.605E-02	1.584E-02	1.508E-02	1.293E-02	5.407E-03	0.000E+00	0.000E+00
Th-232	Th-232	1.000E+00	4.580E-03	4.549E-03	4.488E-03	4.273E-03	3.660E-03	1.521E-03	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	1.335E-03	1.269E-03	1.147E-03	8.020E-04	2.848E-04	5.512E-06	0.000E+00	0.000E+00
U-234	U-234	1.339E-06	1.788E-09	1.700E-09	1.535E-09	1.074E-09	3.813E-10	7.381E-12	0.000E+00	0.000E+00
U-234	U-238	1.000E+00	1.925E-09	5.520E-09	1.165E-08	2.447E-08	2.525E-08	1.611E-09	0.000E+00	0.000E+00
U-234	U-238	1.339E-06	2.578E-15	7.392E-15	1.560E-14	3.277E-14	3.381E-14	2.157E-15	0.000E+00	0.000E+00
U-234	ΣDOSE(j)		1.335E-03	1.269E-03	1.147E-03	8.020E-04	2.848E-04	5.514E-06	0.000E+00	0.000E+00
U-235	U-235	1.000E+00	4.271E-03	4.082E-03	3.728E-03	2.713E-03	1.086E-03	3.533E-05	0.000E+00	0.000E+00
U-238	U-238	5.450E-07	6.485E-10	6.163E-10	5.566E-10	3.891E-10	1.379E-10	2.622E-12	0.000E+00	0.000E+00
U-238	U-238	1.000E+00	1.656E-02	1.582E-02	1.442E-02	1.042E-02	4.090E-03	1.272E-04	0.000E+00	0.000E+00
U-238	ΣDOSE(j)		1.656E-02	1.582E-02	1.442E-02	1.042E-02	4.090E-03	1.272E-04	0.000E+00	0.000E+00
U-238	U-238	1.339E-06	2.218E-08	2.118E-08	1.931E-08	1.395E-08	5.477E-09	1.703E-10	0.000E+00	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration  
 Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	S(j,t), pCi/g							
(j)	(i)	t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03								
Ac-227	Ac-227	1.000E+00	3.100E-02	2.690E-02	2.026E-02	7.510E-03	4.408E-04	2.159E-08	1.048E-20	0.000E+00
Ac-227	Pa-231	1.000E+00	0.000E+00	8.996E-04	2.248E-03	4.049E-03	2.538E-03	1.209E-04	1.724E-08	5.976E-22
Ac-227	U-235	1.000E+00	0.000E+00	9.672E-09	7.481E-08	4.969E-07	1.152E-06	2.298E-07	1.060E-10	1.265E-23
Ac-227	ΣS(j):		3.100E-02	2.780E-02	2.251E-02	1.156E-02	2.980E-03	1.211E-04	1.735E-08	6.102E-22
Pa-231	Pa-231	1.000E+00	3.100E-02	2.966E-02	2.714E-02	1.991E-02	8.213E-03	3.702E-04	5.281E-08	1.830E-21
Pa-231	U-235	1.000E+00	0.000E+00	6.275E-07	1.723E-06	4.213E-06	5.215E-06	7.842E-07	3.363E-10	3.913E-23
Pa-231	ΣS(j):		3.100E-02	2.966E-02	2.715E-02	1.991E-02	8.218E-03	3.710E-04	5.314E-08	1.869E-21
Pb-210	Pb-210	1.000E+00	1.000E+00	9.480E-01	8.520E-01	5.863E-01	2.015E-01	4.797E-03	1.104E-07	6.452E-24
Pb-210	Pb-210	1.339E-06	1.339E-06	1.269E-06	1.141E-06	7.850E-07	2.698E-07	6.423E-09	1.478E-13	8.639E-30
Pb-210	Ra-226	1.000E+00	0.000E+00	2.992E-02	8.241E-02	2.040E-01	2.643E-01	5.219E-02	9.662E-05	1.708E-14
Pb-210	Th-230	1.000E+00	0.000E+00	5.370E-06	4.568E-05	4.180E-04	2.234E-03	5.828E-03	6.376E-03	6.174E-03
Pb-210	U-234	1.000E+00	0.000E+00	1.078E-11	2.728E-10	8.081E-09	1.180E-07	6.866E-07	8.712E-07	8.440E-07
Pb-210	U-238	1.000E+00	0.000E+00	7.815E-18	5.906E-16	5.730E-14	2.371E-12	3.514E-11	5.722E-11	5.551E-11
Pb-210	ΣS(j):		1.000E+00	9.779E-01	9.344E-01	7.907E-01	4.681E-01	6.282E-02	6.473E-03	6.174E-03
Po-210	Pb-210	1.000E+00	0.000E+00	7.515E-01	7.799E-01	5.380E-01	1.849E-01	4.402E-03	1.013E-07	5.921E-24
Po-210	Po-210	1.000E+00	1.000E+00	1.291E-01	2.152E-03	1.286E-09	2.128E-27	0.000E+00	0.000E+00	0.000E+00
Po-210	Ra-226	1.000E+00	0.000E+00	1.552E-02	6.274E-02	1.769E-01	2.371E-01	4.732E-02	8.773E-05	1.551E-14
Po-210	Th-230	1.000E+00	0.000E+00	2.117E-06	2.998E-05	3.430E-04	1.955E-03	5.201E-03	5.698E-03	5.518E-03
Po-210	U-234	1.000E+00	0.000E+00	3.457E-12	1.587E-10	6.347E-09	1.019E-07	6.115E-07	7.786E-07	7.543E-07
Po-210	U-238	1.000E+00	0.000E+00	2.120E-18	3.091E-16	4.313E-14	2.018E-12	3.121E-11	5.114E-11	4.961E-11
Po-210	ΣS(j):		1.000E+00	8.961E-01	8.448E-01	7.152E-01	4.240E-01	5.692E-02	5.787E-03	5.518E-03
Ra-226	Ra-226	1.000E+00	1.000E+00	9.684E-01	9.082E-01	7.255E-01	3.819E-01	4.043E-02	6.607E-05	1.166E-14
Ra-226	Ra-226	1.339E-06	1.339E-06	1.297E-06	1.216E-06	9.715E-07	5.114E-07	5.413E-08	8.847E-11	1.561E-20
Ra-226	Th-230	1.000E+00	0.000E+00	3.483E-04	1.012E-03	3.027E-03	6.813E-03	1.055E-02	1.090E-02	1.055E-02
Ra-226	Th-230	1.339E-06	0.000E+00	4.664E-10	1.355E-09	4.053E-09	9.123E-09	1.413E-08	1.459E-08	1.412E-08
Ra-226	U-234	1.000E+00	0.000E+00	1.043E-09	8.922E-09	8.328E-08	4.669E-07	1.329E-06	1.489E-06	1.442E-06
Ra-226	U-234	1.339E-06	0.000E+00	1.396E-15	1.195E-14	1.115E-13	6.252E-13	1.780E-12	1.994E-12	1.931E-12
Ra-226	U-238	1.000E+00	0.000E+00	1.006E-15	2.558E-14	7.693E-13	1.168E-11	7.423E-11	9.788E-11	9.484E-11
Ra-226	U-238	1.339E-06	0.000E+00	1.347E-21	3.425E-20	1.030E-18	1.564E-17	9.939E-17	1.311E-16	1.270E-16
Ra-226	ΣS(j):		1.000E+00	9.688E-01	9.093E-01	7.286E-01	3.888E-01	5.098E-02	1.096E-02	1.055E-02
Pb-210	Ra-226	1.339E-06	0.000E+00	4.006E-08	1.103E-07	2.732E-07	3.539E-07	6.989E-08	1.294E-10	2.287E-20
Pb-210	Th-230	1.339E-06	0.000E+00	7.191E-12	6.116E-11	5.597E-10	2.991E-09	7.804E-09	8.537E-09	8.266E-09
Pb-210	U-234	1.339E-06	0.000E+00	1.443E-17	3.653E-16	1.082E-14	1.580E-13	9.194E-13	1.167E-12	1.130E-12
Pb-210	U-238	1.339E-06	0.000E+00	1.046E-23	7.908E-22	7.672E-20	3.175E-18	4.705E-17	7.662E-17	7.432E-17
Pb-210	ΣS(j):		0.000E+00	4.007E-08	1.104E-07	2.737E-07	3.569E-07	7.769E-08	8.667E-09	8.267E-09
Ra-228	Ra-228	1.000E+00	2.040E-01	1.752E-01	1.292E-01	4.453E-02	2.122E-03	5.010E-08	3.021E-21	0.000E+00
Ra-228	Th-232	1.000E+00	0.000E+00	2.359E-02	6.126E-02	1.306E-01	1.652E-01	1.665E-01	1.653E-01	1.611E-01
Ra-228	ΣS(j):		2.040E-01	1.988E-01	1.905E-01	1.751E-01	1.674E-01	1.665E-01	1.653E-01	1.611E-01
Th-228	Ra-228	1.000E+00	0.000E+00	5.729E-02	1.042E-01	6.737E-02	3.649E-03	8.632E-08	5.206E-21	0.000E+00
Th-228	Th-228	1.000E+00	2.100E-01	1.461E-01	7.075E-02	5.589E-03	3.958E-06	3.742E-17	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	0.000E+00	3.895E-03	2.542E-02	1.074E-01	1.640E-01	1.665E-01	1.653E-01	1.611E-01
Th-228	ΣS(j):		2.100E-01	2.073E-01	2.004E-01	1.804E-01	1.676E-01	1.665E-01	1.653E-01	1.611E-01

Individual Nuclide Soil Concentration  
Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	S(j,t), pCi/g							
(j)	(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Th-230	Th-230	1.000E+00	8.170E-01	8.170E-01	8.169E-01	8.166E-01	8.159E-01	8.132E-01	8.057E-01	7.801E-01
Th-230	Th-230	1.339E-06	1.094E-06	1.094E-06	1.094E-06	1.093E-06	1.092E-06	1.089E-06	1.079E-06	1.045E-06
Th-230	U-234	1.000E+00	0.000E+00	4.830E-06	1.387E-05	3.989E-05	8.193E-05	1.098E-04	1.101E-04	1.066E-04
Th-230	U-234	1.339E-06	0.000E+00	6.468E-12	1.857E-11	5.341E-11	1.097E-10	1.471E-10	1.475E-10	1.428E-10
Th-230	U-238	1.000E+00	0.000E+00	6.970E-12	5.916E-11	5.373E-10	2.806E-09	6.835E-09	7.244E-09	7.014E-09
Th-230	U-238	1.339E-06	0.000E+00	9.333E-18	7.922E-17	7.195E-16	3.757E-15	9.152E-15	9.700E-15	9.391E-15
Th-230	$\Sigma S(j)$ :		8.170E-01	8.170E-01	8.169E-01	8.167E-01	8.159E-01	8.133E-01	8.059E-01	7.802E-01
Th-232	Th-232	1.000E+00	2.110E-01	2.110E-01	2.110E-01	2.109E-01	2.108E-01	2.102E-01	2.087E-01	2.033E-01
U-234	U-234	1.000E+00	5.370E-01	5.138E-01	4.702E-01	3.450E-01	1.423E-01	6.425E-03	9.198E-07	3.229E-20
U-234	U-234	1.339E-06	7.190E-07	6.879E-07	6.296E-07	4.619E-07	1.906E-07	8.603E-09	1.232E-12	4.323E-26
U-234	U-238	1.000E+00	0.000E+00	1.494E-06	4.102E-06	1.003E-05	1.242E-05	1.868E-06	8.026E-10	9.400E-23
U-234	U-238	1.339E-06	0.000E+00	2.000E-12	5.492E-12	1.343E-11	1.663E-11	2.502E-12	1.075E-15	1.259E-28
U-234	$\Sigma S(j)$ :		5.370E-01	5.138E-01	4.702E-01	3.450E-01	1.424E-01	6.427E-03	9.206E-07	3.238E-20
U-235	U-235	1.000E+00	3.100E-02	2.966E-02	2.715E-02	1.991E-02	8.218E-03	3.710E-04	5.314E-08	1.869E-21
U-238	U-238	5.450E-07	3.014E-07	2.883E-07	2.639E-07	1.936E-07	7.990E-08	3.607E-09	5.167E-13	1.817E-26
U-238	U-238	1.000E+00	5.530E-01	5.291E-01	4.842E-01	3.552E-01	1.466E-01	6.618E-03	9.480E-07	3.334E-20
U-238	$\Sigma S(j)$ :		5.530E-01	5.291E-01	4.842E-01	3.552E-01	1.466E-01	6.618E-03	9.480E-07	3.334E-20
U-238	U-238	1.339E-06	7.405E-07	7.084E-07	6.484E-07	4.757E-07	1.963E-07	8.862E-09	1.269E-12	4.464E-26

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 3.14 seconds

**ATTACHMENT 7**

**COVER THICKNESS CALCULATION RESULTS FOR TARGET  
MAXIMUM RISK OF 3X10-4**

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	10 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<a href="#"><i>Secular Equilibrium PRG for Ra-226</i></a>	<b>7.62E-01</b>	<b>2.04E+02</b>	<b>9.02E-02</b>	<b>8.06E-02</b>

# Site-specific

## Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	5.78E-05	2.15E-07	4.88E-04	5.46E-04
*Total Risk	5.78E-05	2.15E-07	4.88E-04	5.46E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	20 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<a href="#"><i>Secular Equilibrium PRG for Ra-226</i></a>	<b>7.62E-01</b>	<b>2.04E+02</b>	<b>2.28E-01</b>	<b>1.75E-01</b>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	5.78E-05	2.15E-07	1.93E-04	2.51E-04
*Total Risk	5.78E-05	2.15E-07	1.93E-04	2.51E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	20 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<i>Secular Equilibrium PRG for Ra-226</i>	<i>7.62E-01</i>	<i>2.04E+02</i>	<i>2.28E-01</i>	<i>1.75E-01</i>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	7.88E-05	2.94E-07	2.63E-04	3.42E-04
*Total Risk	7.88E-05	2.94E-07	2.63E-04	3.42E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	30 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<a href="#"><i>Secular Equilibrium PRG for Ra-226</i></a>	<b>7.62E-01</b>	<b>2.04E+02</b>	<b>5.72E-01</b>	<b>3.26E-01</b>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	7.88E-05	2.94E-07	1.05E-04	1.84E-04
*Total Risk	7.88E-05	2.94E-07	1.05E-04	1.84E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	30 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<i>Secular Equilibrium PRG for Ra-226</i>	<i>7.62E-01</i>	<i>2.04E+02</i>	<i>5.72E-01</i>	<i>3.26E-01</i>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	1.16E-04	4.31E-07	1.54E-04	2.70E-04
*Total Risk	1.16E-04	4.31E-07	1.54E-04	2.70E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	30 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<a href="#"><i>Secular Equilibrium PRG for Ra-226</i></a>	<b>7.62E-01</b>	<b>2.04E+02</b>	<b>5.72E-01</b>	<b>3.26E-01</b>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	1.31E-04	4.89E-07	1.75E-04	3.07E-04
*Total Risk	1.31E-04	4.89E-07	1.75E-04	3.07E-04

# Site-specific

## Outdoor Worker Soil Inputs

Variable	Outdoor Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762
City (Climate Zone)	Default	Default
C (PEF Dispersion Constant)	216.108	216.108
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	40 cm
F(x) (function dependent on $U_{\text{m}}/U_c$ ) unitless	0.194	0.194
PEF (particulate emission factor) m <sup>-3</sup> /kg	1359344438	1359344438
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	93.77
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>-2</sup>	1000000 m <sup>-2</sup>	2000 m <sup>-2</sup>
ED <sub>ow</sub> (exposure duration - outdoor worker) yr	25	25
EF <sub>ow</sub> (exposure frequency - outdoor worker) day/yr	225	225
ET <sub>ow</sub> (exposure time - outdoor worker) hr/day	8	8
IRA <sub>ow</sub> (inhalation rate - outdoor worker) m <sup>-3</sup> /day	60	60
IRS <sub>ow</sub> (soil intake rate - outdoor worker) mg/day	100	100
t <sub>ow</sub> (time - outdoor worker) yr	25	25
TR (target cancer risk) unitless	1.0E-06	1.0E-06
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.69
U <sub>c</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

# Site-specific Outdoor Worker PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/g)	Inhalation PRG TR=1.0E-06 (pCi/g)	External Exposure PRG TR=1.0E-06 (pCi/g)	Total PRG TR=1.0E-06 (pCi/g)
<i>Secular Equilibrium PRG for Ra-226</i>	<i>7.62E-01</i>	<i>2.04E+02</i>	<i>1.28E+00</i>	<i>4.77E-01</i>

# Site-specific Outdoor Worker Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Total Risk
*Secular Equilibrium Risk for Ra-226	1.64E-04	6.12E-07	9.76E-05	2.62E-04
*Total Risk	1.64E-04	6.12E-07	9.76E-05	2.62E-04